WORLD ANIMAL REVIEW

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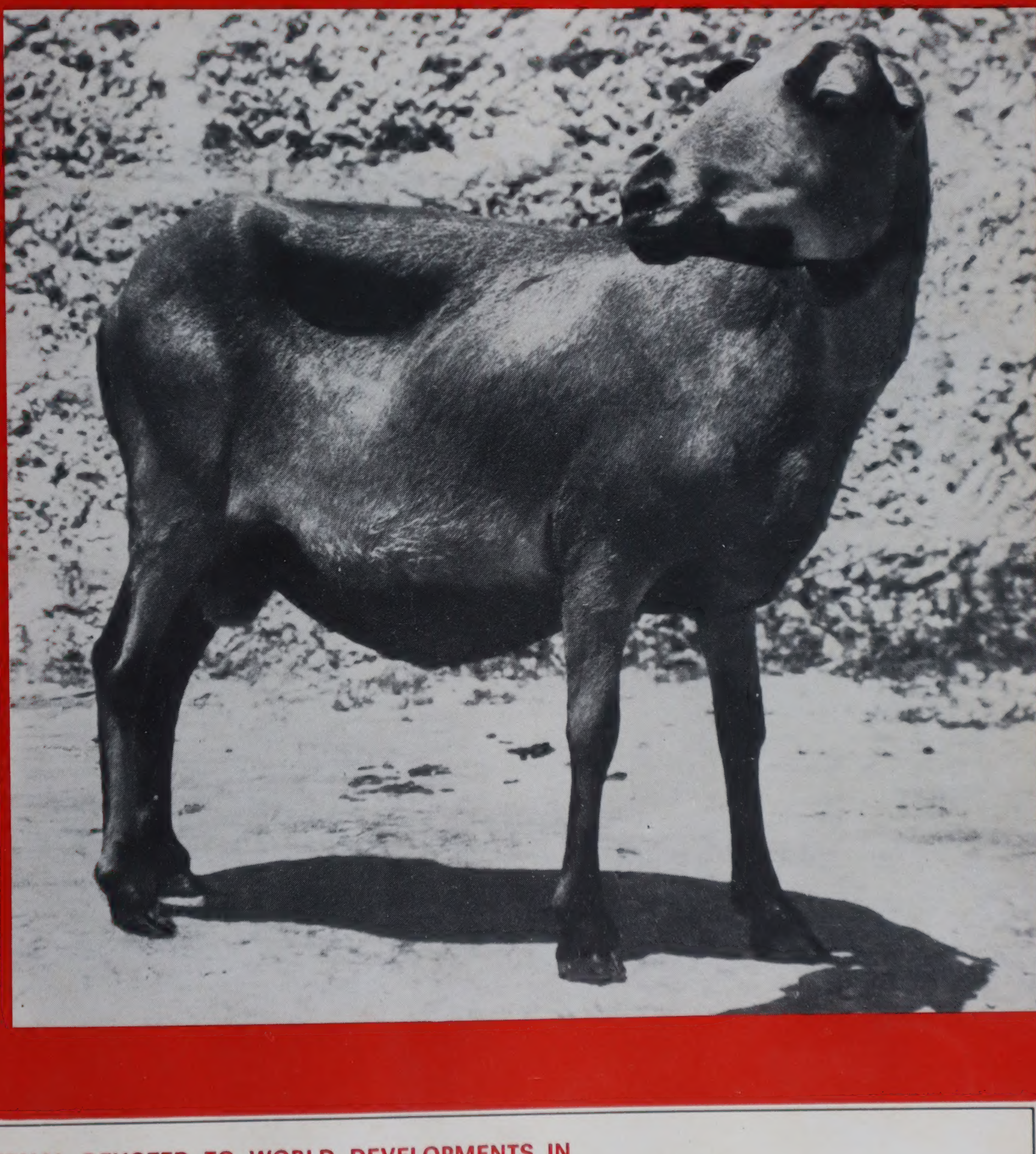

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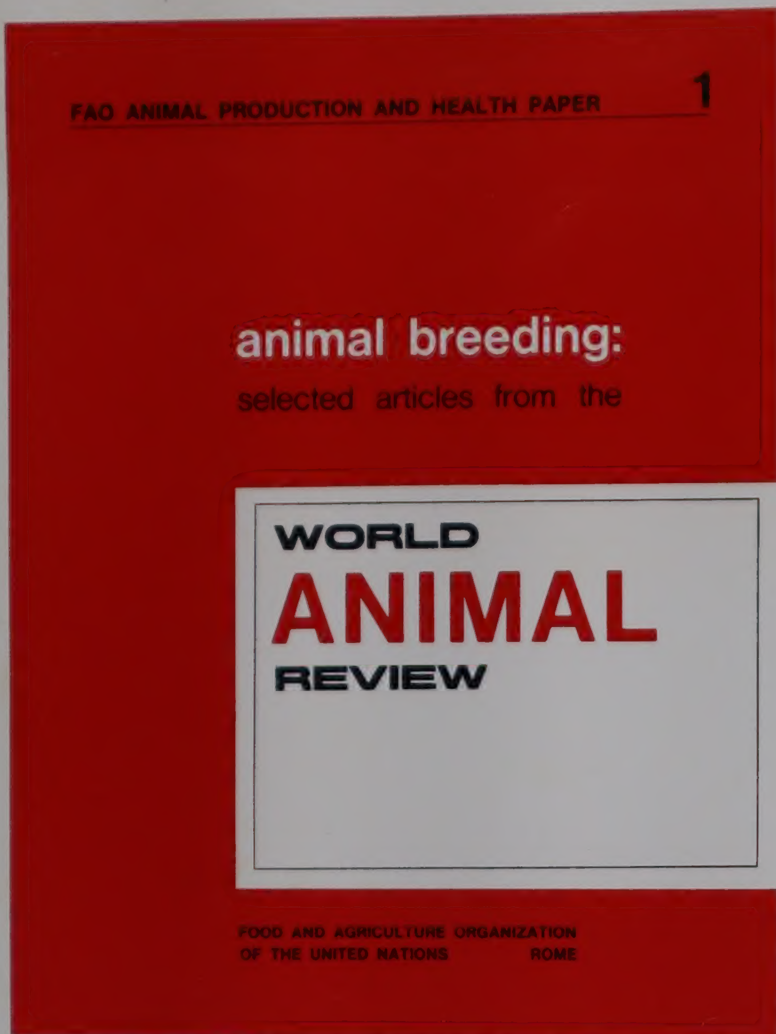

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FAO Animal Production and Health Paper No. 1 is a volume containing articles on animal breeding published in the first twenty issues of the *World Animal Review*. It presents the experience and the results of the work of animal breeders and geneticists from sixteen countries. Although the main focus of the articles is on animal breeding in developing areas of the world, information from developed countries is also included. The publication is designed to provide a ready and easy reference to those concerned with the improvement of milk and meat production, particularly in the warmer areas of the world.

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Note: The number in brackets refers to the issue of *World Animal Review* in which the article originally appeared.

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WORLD ANIMAL REVIEW

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WORLD ANIMAL REVIEW [abbreviation: **Wld. Anim. Rev.** (FAO)] is prepared by FAO's Animal Production and Health Division, which is one of five divisions in the Agriculture Department. The Division is subdivided into three technical services concerned with livestock research and education, meat and milk development and animal health.

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Technical Editor: P. Mahadevan.

COVER: Barbados Blackbelly sheep

Corrigenda

In WORLD ANIMAL REVIEW No. 23 the title of the article by B.G. Katpatal should read: "Results of the All India Coordinated Research Project on Cattle." The caption for Figure 1, p. 6 should read "Half-bred Friesian X Gir." The identification of the cover photo should read "Ongole bull."

Dairy development in India: Part I

Mogens Jul

The cattle population of India is about 180 million, and the buffalo population is 60 million. Despite these large populations, total milk production in the country is low; even today the commercial daily distribution of milk in India is only 2.7 million litres. The main reason for this is that, especially in the farming areas, cattle have been looked upon mainly as a source of draught power and of manure to be used for fuel and, sometimes, for fertilizer. Some cattle and buffaloes are kept in the cities to secure a supply of milk for their owners. There are also commercial enterprises in the cities supplying milk from cattle and buffaloes held within the city premises. In the later colonial days efforts were made to collect milk in the rural areas for direct sale in towns or for processing through dairies, and this gradually led to increasing milk supplies to the main population centres.

Over the last 30 years a remarkable development took place in the Kaira district in Gujarat. Some commercial dairies arranged milk collection from farmers for sale in the towns and for manufacture of ghee. Some farmers became dissatisfied with the prices offered them, and organized a few cooperative societies, which eventually established their own dairy. Today this is a flourishing industry. The main dairy is that of AMUL (Anand Milk Union Ltd., now named Kaira District Cooperative Milk Producers' Union) in the town of Anand which receives milk and processes it into cheese and dried skim milk, or transports it by road often to Bombay or even Delhi. The milk is obtained from some 225 000 milk producers, who deliver milk morning and evening to village collection centres where it is tested for its fat content. The milk producers' union organizes the transport of the milk to Anand and its further utilization.

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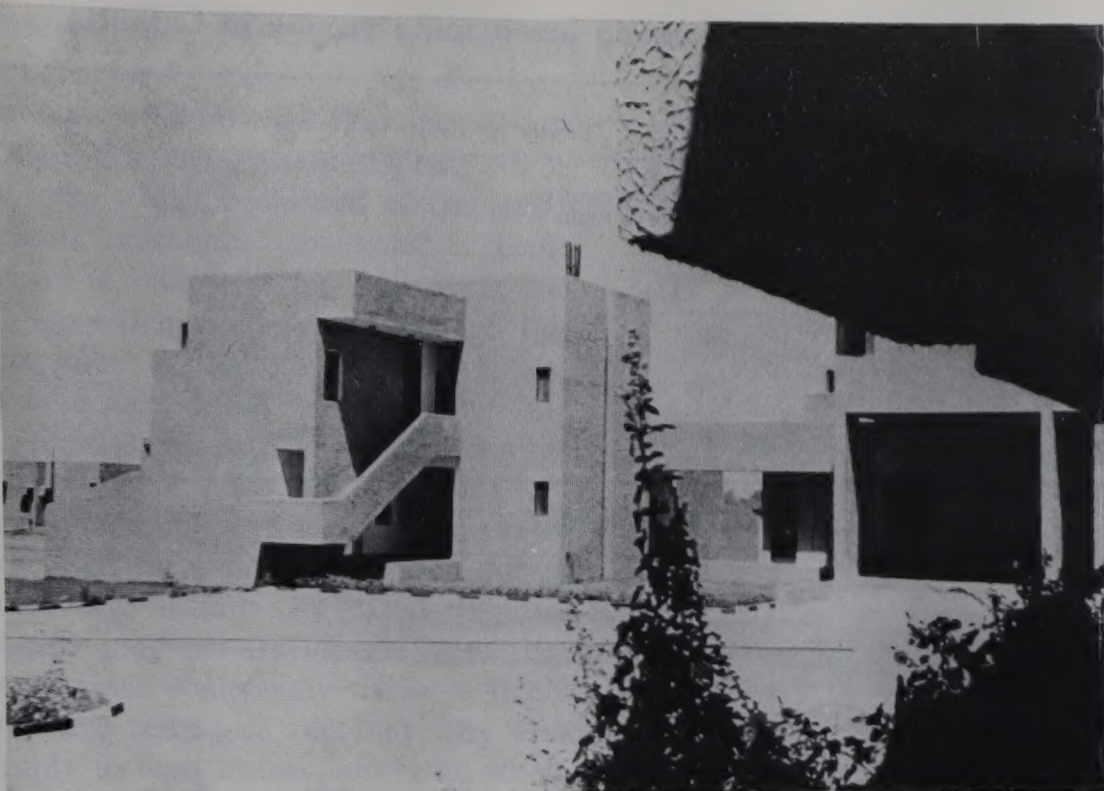
The producer is paid on each delivery of milk for the previous delivery. At the collection centre, he has an opportunity for purchasing cattle feed; in addition, the union has arranged for the feeds to be sold by the societies and for extension services to be provided to farmers on the growing of green fodder, and supplies the necessary seeds. The union also arranges for artificial insemination of cattle and, mainly, buffaloes (which produce the greater part of the milk) and has a very well-organized veterinary service based at Anand.

"Operation Flood"

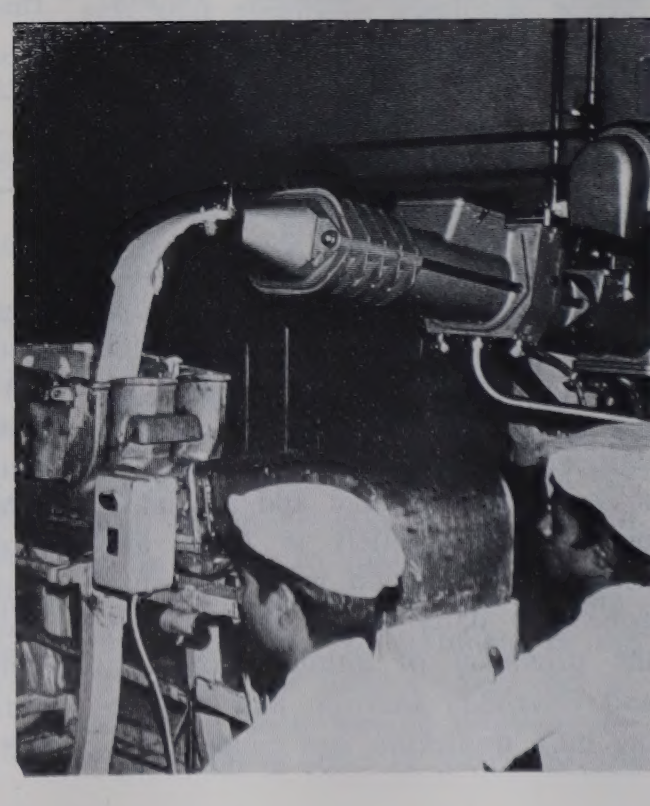
The success of the Kaira undertaking was so large that it was felt it should be duplicated in other areas. Under the leadership of the managing director of the AMUL organization, Dr. V. Kurien, a National Dairy Development Board (NDDB) was established to carry out advisory services for the establishment of dairy systems in other areas of India. The NDDB was particularly interested in organizing milk supplies to the four main cities of India (Bombay, Calcutta, Delhi and Madras) and convinced the Government of India that a project should be launched to attempt to organize the supply of milk to these cities. Until recently milk in these cities was obtained from private vendors or through city milk schemes; the latter supplied only a minor part of the total milk market. The Government of India obtained support from various international sources, primarily from the World Food Programme (WFP) but also from UNICEF, SIDA,[1] and DANIDA,[2] for this project, which came to be known as "Operation Flood".

The concept of the project was for WFP to supply 126 000 metric tons of dried skim milk and 42 000 tons of butter oil, the total value of

[1] Swedish International Development Authority.
[2] Danish International Development Agency.



Top: school for dairy technologists at Mehsana, Gujarat. *Centre, left:* automatic bulk vending station, New Delhi; *right:* morning milk delivery, Kaira district. *Below, left:* tank cars ready for delivery to automatic bulk vending stations, New Delhi; *right:* continuous butter manufacture at the Kaira District Milk Producers' Cooperative, Anand.



this gift being estimated at US$ 106 million, about 900 million rupees. The donated commodities would be recombined into milk and the product sold as fresh milk in the four cities. The funds thus generated were to be used for building up a dairy supply system with the necessary organizations in rural areas, dairies in supply areas, feed mills, a transport system, and dairies in the cities. The system was to be managed by a separate corporation, the Indian Dairy Corporation, set up by the Government of India, on the understanding that the NDDB would supply technical expertise.

While the project included the building up of milk producers' organizations in the rural areas and facilities for promoting animal husbandry, it was obvious that it would be necessary first to build up a system which was capable of accepting, handling and transporting the milk which would be collected. In the first six years of its existence the project has completed city dairies in Bombay, Delhi and Madras, while another one in Calcutta is being constructed. In addition, about 18 so-called feeder balancing plants were built in rural areas, most of them with a capacity of about 100 000 litres of milk daily. These rural dairies process milk and either transport it to the main cities or convert it into dried skim milk and ghee or butter. The corporation had also constructed the first 30 tank cars and a fleet of road tankers. To provide for the necessary inputs, some 10 feed mills were built. A special feature of the project is the distribution of additional milk for Indian cities through automatic bulk vending machines, as described later.

By the time the WFP evaluation mission of the project visited India, the amount invested was about 400 million rupees, used mainly for building up the system of feed plants, dairies in rural and urban areas, a milk transport system and automatic bulk vending outlets in Delhi and Madras. In addition, much effort had gone into dairy cattle improvement, the provision of animal husbandry and veterinary services, and organizing milk producers into cooperatives.

TABLE 1. — **Food intakes among low-income groups in Calcutta** [1]

	Energy			*Protein*		
	Intake	Requirement	%	Intake	Requirement	% [2]
	kcal			*g*		
Pre-school child	500	1 200	*42*	15	18	*54*
School child	850	1 900	*45*	25	37	*44*
Adult	1 220	2 700	*45*	35	50	*46*
	Vitamin A			*Calcium*		
	Intake	Requirement	%	Intake	Requirement	%
	I.U.			*mg*		
Pre-school child	300	900	*33*	200	450	*44*
School child	1 000	3 000	*33*	230	650	*35*
Adult	1 500	3 000	*50*	275	450	*61*

Source: Hindustan Thompson (1972).
[1] 1969-70. — [2] Corrected for protein quality.

TABLE 2. — **Daily energy and nutrient requirements for Indians compared to the composition of milk**

	Requirement			Amount contained in 100 g milk
Age, years Sex	1-2	12-16 M	22-56 M	
Energy, kcal	1 200	2 500	2 800	65-100
Protein (ref), g	17	53	55	3.2 -4.0
Vitamin A (I.U.)	900	3 000	3 000	120-160
Calcium, mg	450	650	450	110-160
Thiamin, mg	0.5	1.2	1.3	0.04
Riboflavin, mg	0.6	1.7	1.8	0.16

Source: Indian Council of Medical Research (1968).
NOTE. Requirement estimates vary widely according to different schools of nutrition.

Supplying milk to vulnerable urban groups

Nutritional status. One of the objectives of WFP support to the project is that it should improve the nutrition of vulnerable groups in the cities. To estimate to what extent this has been achieved, food intakes among low-income groups were considered in relation to their nutritional requirements. Data on food intakes are available for Calcutta and are reproduced in Table 1. The table suggests that intakes are somewhere around 33 to 60 percent of estimated requirements; in most cases they are about 45 percent. The situation is likely to be similar in the other three cities.

This indicates that the low-income population is considerably undernourished. The composition of the diet by itself is fairly well balanced, since it does not appear grossly deficient in any one of the nutrients considered. The reason for nutritional disorders is simply low food intake. To rectify

this situation one would have to increase food intake so that the total amount of food eaten per day is sufficient for energy requirements to be met by a diet composed of the ingredients currently consumed. Little need is indicated for improving the composition of the diet, although this statement is, of course, subject to the qualification that requirements are correctly estimated. There may be cases where infectious disease, especially among small children, increases the need for improved nutrition during recovery. These increased requirements may pertain especially to protein, since some body tissue is likely to have been lost, but they may also apply to food energy, since the whole body is likely to have become depleted during the period of illness. However, as long as general food intakes are as low as 50 percent of requirements, the main effort must be in the direction of increased total food intake, except possibly for cases where specific nutrients, such as vitamin A, can be supplied relatively cheaply.

Milk in urban nutrition. Table 2 gives requirements of food energy and of the nutrients considered, as estimated by the Indian Council for Medical Research. It also lists the content of 100 g of milk. A range is given because of the difference between cow's milk and buffalo milk.

This table shows that if one were to achieve, through added quantities of milk, an improvement of, say, 10 percent of the daily requirement of energy, protein, vitamin A, riboflavin, or calcium, the milk intake would have to be increased from 30 to 450 g per day. Where standardized milk is considered, much higher increases would be necessary.

One may now refer to Table 3, which provides milk consumption data for various income groups in Calcutta. It indicates that the lowest income groups would have to increase their milk intake very substantially before it would have any significant effect on their nutritional status; the picture is not basically different in Bombay, Delhi or Madras. This leads to the conclusion that it would be unrealistic to assume that the nutritional status of low-income groups in these cities could be significantly improved by even very considerable increases in milk supplies.

TABLE 3. — **Milk consumption in Calcutta**
(Adjusted to price index for October 1974)

Expenditure per month per caput	Milk per caput per day
Rupees	*Grams*
<35	20
35- 70	39
71-105	87
106-175	133
>175	238

Source: Hindustan Thompson (1972).

Milk compared to other foods. Table 4 suggests the most likely reason for the very low milk intake in low-income groups, namely that milk is a comparatively expensive commodity. Very low-income groups must select the cheapest local staple as their main food; therefore, they cannot rely on milk for any significant part of their diet. Table 4 also suggests that it might be unwise to encourage such groups to consume more milk if it is to be purchased at regular market prices. Since income is limited, such increased milk intake could only be achieved through a reduction of expenditure on other foods. Thus buying 50 ml more milk might deprive an individual of 300 grams of wheat flour (*atta*); he might get 50 additional calories in the form of milk, but he would have to forego 700 calories of atta. Since food energy intake is already very low, such a change would have a highly undesirable effect.

TABLE 4. — **Lowest observed food prices in Calcutta, 1970, and calculated price per calorie (kcal)**

	Rs/kg	kcal/kg	Rs per 1 000 kcal
Rice (open market)	1.97	3 600	0.55
Rice (control)	1.26	3 600	0.35
Wheat atta (open market)	1.03	3 600	0.29
Wheat atta (control)	0.96	3 600	0.27
Legumes	1.50	1 400	0.93
Mustard oil	5.12	8 850	0.58
Milk (buffalo)	2.02	1 000	2.02
Potatoes	0.65	700	0.92
Vegetables	0.70	200	3.50
Fish	2.35	1 000	2.35
Meat	2.82	2 000	1.41

Source: Hindustan Thompson (1972).

It would also be unrealistic to assume that the purchase of milk could replace non-food purchases. Food is already by far the largest share of the daily expenditure: 70 percent for very low-income groups. One could hardly expect such families to use more of their truly meagre income for food.

Supplementary feeding programmes. Faced with the fact that quite large population groups in Indian cities are nutritionally deprived, one might conclude that there is an acute need for supplementary feeding programmes. Therefore, one of the objectives of the WFP project is to provide for a certain amount of free distribution of milk to vulnerable groups in cities, although the actual amount is small. Tables 1 and 5 suggest that enormous quantities would be required, but one could not expect the milk supply and distribution systems to provide such large amounts of milk free. If this were to be done, it would be necessary to pay the rural producer much lower prices. However, as discussed in detail below, the rural population in the milk shed areas is economically and nutritionally no better off than the city populations. Thus, expecting them to supply milk cheaper to help needy groups in the cities would be asking one deprived group to give to another.

Another solution would be for municipalities, state governments, or the Government of India to meet the expenses of such feeding programmes. This would in effect be a vast income

TABLE 5. — **Distribution of disposable personal income**

Disposable annual income (Rs)	Rural Sector	Urban Sector	All-India
	Percent of households		
<1 000	23.5	8.5	18.5
1 000- 2 000	36.6	21.5	34.5
2 001- 4 000	27.4	33.2	30.2
4 001- 6 000	6.4	14.4	6.8
6 001-10 000	3.7	11.2	5.0
10 001-15 000	1.6	5.5	2.4
15 001-20 000	0.5	2.8	1.9
20 001-30 000	0.2	1.8	0.4
30 000 up	0.1	1.1	0.3

Source: Gujarat, Bureau of Economics and Statistics (1973).
NOTE. Calculated from data for 1962/63. Adjusted according to price index October 1974.

redistribution programme; Table 5 indicates that to have any real impact on the nutritional status in India one would have to consider income redistribution programmes on a scale that is unlikely to be feasible.

Notwithstanding this, the Government of India has taken on the responsibility, under the present five-year Plan, of providing supplementary feeding to no less than 26 million individuals. However, the Government has also accepted the fact, which might be deduced from Table 4, that where supplementary feeding programmes are undertaken on such vast scales, it is uneconomic and possibly impractical to use milk as a food supplement. It is generally considered that in order to have any impact at all, a supplementary feeding programme should supply no less than 400 kcal and 15 g of protein per day. Table 6 indicates, for various foods used in supplementary feeding programmes, the cost in paise per person. One will notice that such vegetable mixes as, for instance, the Indian Bal Ahar, which is a supplementary food material in use in very large quantities, would be far cheaper per beneficiary than milk. In addition, milk is a perishable, bulky food, difficult to distribute, easily lost and difficult to store. Therefore, even where funds are available for supplementary feeding in India, milk is not the most suitable food for this purpose.

Effect on nutrition

Income. Table 5 contains estimated annual incomes in rural and urban sectors of the Indian population. About 80 percent of all Indians live in what are characterized as rural areas (about 70 percent of the families are actively engaged in agriculture). Incomes are considerably lower in rural areas than in cities; about 60 percent of rural households have an annual disposable income of less than Rs. 2 000 (approx. US$ 230), while the corresponding percentage for the urban sector is 30. As will be shown below, rural populations are somewhat better off nutritionally than urban populations at the same income level, but this positive effect is offset by their generally lower average income. Rural populations especially are at nutritional risk because food supply can be very uneven, which can lead to severe nutritional deficiencies. Much evidence has been given by the medical profession to show that malnutrition is more serious in rural areas than among city populations in India.

Economic effect in rural areas. It has already been mentioned that the establishment of an organized milk collection system provides many people in the rural areas with an additional income. From a nutritional point of view this income may be particularly valuable since it is a daily income, more likely to be used for food than those periodic incomes which are derived from other agricultural activities. One study exists of an area in the Kaira district; the data in Table 7 suggest that in areas with so-called adopters (that is, groups which have adopted the cooperative system of dairy production) there has been a doubling of income from dairying. More surprising, however, is that the adopters have also more than doubled their income from other agricultural activities; no doubt this has been due to the general social effects of the existence of an organized milk collection system with the associated cooperative societies.

TABLE 6. — **Prices for various foods, in paise**

	400 kcal	15 g protein
Standard milk	97	67
Double-toned milk	87	37
Extruded veg. food	61	50
Multipurpose food	30	11
Rice	28	46
Home-prepared balanced food	25	25
Bal Ahar	18	20
Wheat	15	21
Groundnut flour	14	6

TABLE 7. — **Farm income, Madiad village (Kaira district)**

	Total	Dairy	
	Rs/year		%
Adopters			
Small (<5 acres)	1 511	1 151	78
Medium (5-10 acres)	3 353	1 917	57
Large (>10 acres)	10 492	3 851	37
Average	4 097	1 985	48
Non-adopters			
Small (<7.5 acres)	752	453	60
Medium (7.5-15 acres)	2 081	1 212	58
Large (> 15 acres)	6 002	2 556	43
Average	1 192	675	57

Source: Srivastava (1970).

Social bias of development. One might suspect that dairy development mainly affects large farmers who have means for investing in improved cattle, feeds, fodder production, and so on (Nyholm *et al.*, 1975). However, Table 8 indicates that a large proportion of milk suppliers to the organized milk systems are landless

farm labourers or farmers with very small holdings (under 1 ha). In fact many data are available to indicate that well-organized dairy development in India will benefit mainly the marginal farmer or the landless agricultural labourer. Not all of these have dairy animals, but Table 9 shows that a very significant proportion do (and one of the objectives of the project is to assist the rural poor in acquiring dairy animals).

In evaluating the data of Table 9 it must be borne in mind that some of the landless in rural areas are engaged in various trades or handicrafts and thus have an income outside of agriculture.

Effect of increased income. One might, of course, suspect that the increased incomes would not be used for food but for other necessities or amenities. To evaluate the effect of increased incomes on nutrition, various food intake data were studied where these could be related to income. To facilitate comparisons, income levels have been adjusted, using the general price index, to 1974 conditions. The results are given in Figures 1 and 2, which concentrate on the very low-income groups. It appears as if the income elasticity of food intake of these groups is very substantial, possibly about 40 percent. This means that if income, as Table 7 suggests, is doubled, food intake will increase by some 40 percent. These studies show that this income elasticity applies to total energy intake as well as to intakes of protein, vitamin A, vitamin B and calcium. It is therefore possible that the project will bring about a nutritional improvement amounting to about 40 percent of present intake in the rural populations affected, some 2 million households or about 12 million persons; the project may thus be the largest and most successful nutritional project yet undertaken in India. This is particularly encouraging because the project is a self-sustaining operation, likely to be self-generating. Thus producers are not helped to tide over a difficult period; instead, they are helped to achieve a permanently improved nutritional status.

TABLE 8. — **Low-income rural populations according to landholding and involvement in dairy production**

	Gujarat Kaira	*Punjab* Ludhiana	*Tamil Nadu* Madurai
	Percent of households		
Landless	26.4	54.7	57.4
Non-farmers	7.3	28.9	41.2
Farm labourers			
With milch animals	8.5	19.6	5.5
Without milch animals	0.6	6.2	10.7
Under 1 ha	22.7	7.1	30.5
Non-farmers	0.4	0.2	1.1
With milch animals	16.5	5.8	12.6
Without milch animals	5.8	1.1	16.8

Source: National Dairy Development Board (1974).

Mobilizing human resources

Producers' cooperatives. One objective of the project is to build up a milk collection system in the rural areas. The plan is that milk producers are to be organized in dairy cooperatives according to the so-called Anand pattern, characterized by societies having only active producers as members; their secretaries and other workers are paid employees, and the societies carry out no lending functions. These requirements seem to make such cooperatives immune from most of the abuses associated with many other types of cooperatives.

This concept of dairy cooperatives is new in most areas, so that organizing large groups of very small milk producers will take time. The Indian Dairy Corporation has accepted that meanwhile it will make use of other collection systems to obtain the necessary milk, but the ultimate target is to rely on milk producers' cooperatives of the Anand type. Building up the network of rural cooperatives is carried out by teams from the NDDB sent into rural areas to help rural producers organize themselves into cooperatives. It is most encouraging to see that very rapid progress is being made; from March 1975 to January 1976 an increase from about 2 500 organized societies to some 4 500 has been achieved. It confirms the wisdom of the programme of the Indian Dairy Corporation in first building up a dairy system. Once the dairy system is capable of handling the milk, rural organizations seem to succeed rapidly.

TABLE 9. — **Village of Sabarkanta district in Gujarat: total number of households and households with milch animals**

	Total number of households	Number having milch animals
Landless labourers	82	22 (27%)
Small farmers	131	100 (76%)
Medium and large farmers	115	100 (87%)

Agricultural inputs. The fact that organizing rural producers takes time has led to delays in another important field. The project provides assistance to rural producers for increasing the productivity of their dairy animals by help to obtain better feed, by provision of veterinary services and by a programme of artificial insemination. The Indian Dairy Corporation believes that such services should be channelled through the dairy cooperatives, because these cooperatives are likely to be more efficient in distributing such inputs. On the whole the cooperatives and the services to the farmers will work better when the producers feel that the cooperatives are managed by them and operated for them. This part of the project is presently gaining momentum and is making a considerable impact on improving rural milk production.

Unions and federations. The milk producers' societies (cooperatives) are joined into unions which manage the dairies, feed mills, advisory services and the milk transport systems. The unions are joined into state dairy federations.

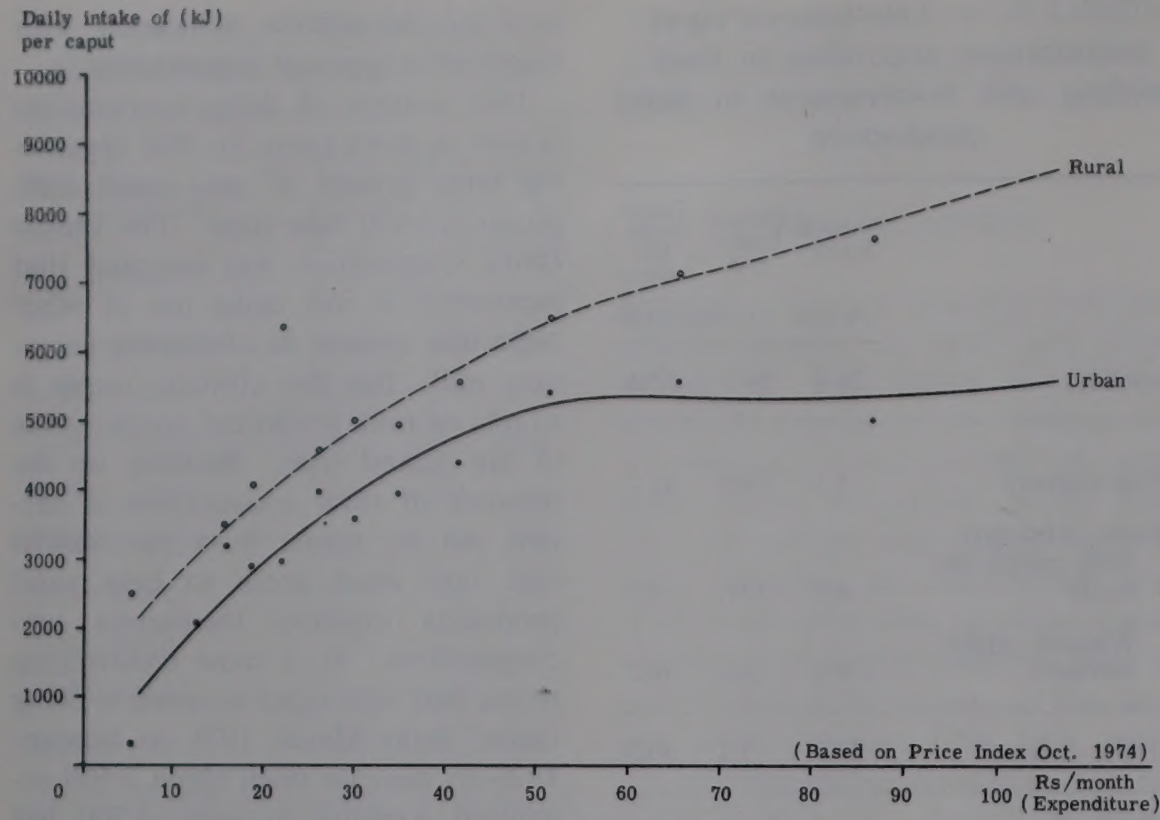


FIGURE 1. — *Energy intake, Gujarat* (RDA: 11 700 kJ)

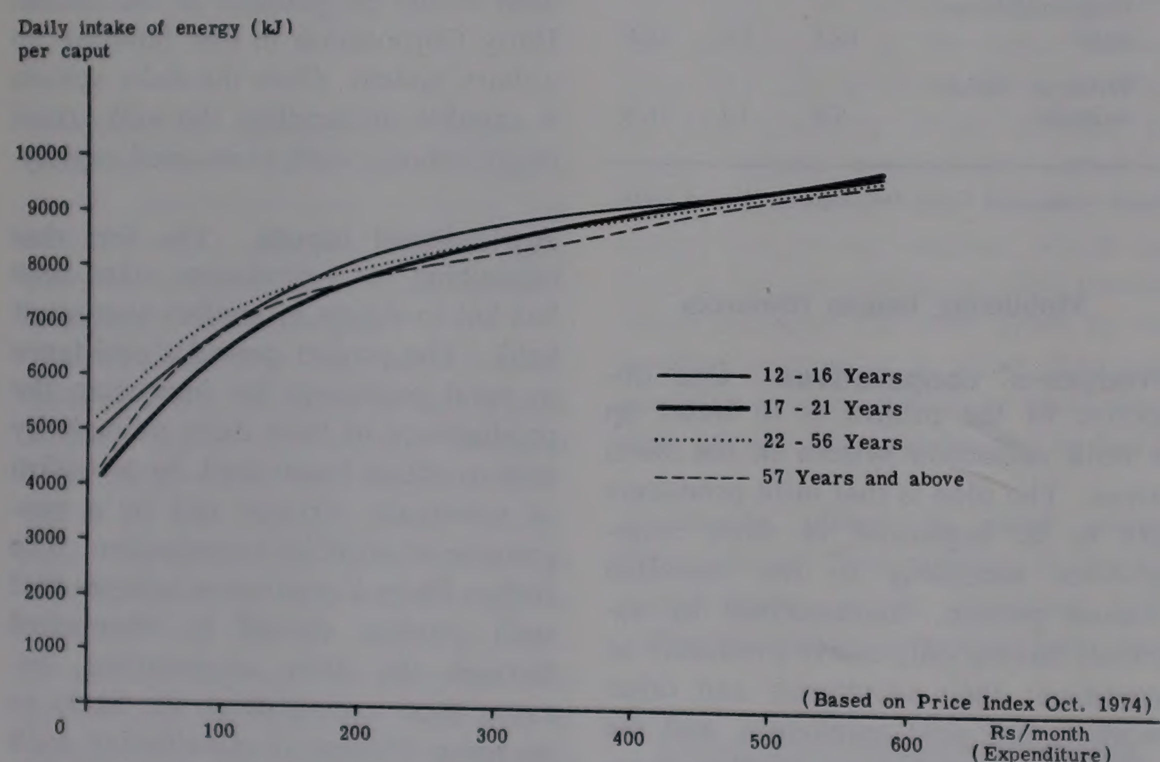


FIGURE 2. — *Energy intake, Calcutta* (RDA: 11 715 kJ — male, 22-56 years)

Social development. The project seems to have a very important effect on economic and social development in rural areas. Landless farm labourers or producers with very small landholdings form up to 80 percent of the producers in most new cooperatives, and dairying may account for up to 70 percent of their income.

The increased income and the provision of adequate food may not be sufficient to bring about a real improvement in the quality of life, so it is most encouraging that the project seems to have contributed substantially to social development in rural areas. Even very small cooperatives in the project area, with extremely limited means, have donated sizable sums for local improvements to schools, libraries, or roads, thus accepting social responsibilities and in fact confirming that the producers, when acting in concert, are capable of bettering their own existence and are conscious of it. Similarly, the large unions of cooperatives have shown a corresponding degree of social responsibility; for instance, one has established a large school for dairy technicians, while another has assisted enormously in helping dairy development in other areas of India.

Employment. One important aspect of the project is its employment generation effect; this goes for increased employment opportunities in rural areas through milk production, as well as for the work involved in the establishment and operation of the many dairies and domestic industries supplying machinery and equipment to these dairies. In fact it is almost overwhelming to see how, in the town of Anand, some 100 manufacturing enterprises have sprung up, supplying various kinds of machinery and equipment to the dairy activities.

The success of dairy cooperatives has led to the establishment of similar cooperatives in other sectors, such as cotton and rice.

The most important effect of the project may be that it has resulted in a large increase in self-reliance and social development in India. ■

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Maize feed supplemented with non-protein nitrogen

R.H. Nelson

Cattle are and will continue to be needed both for making good use of ligno-cellulosic material and for adequate human nutrition. While beef is being produced in many countries without grain, grain feeding speeds up production and increases the volume of beef available. Even though cattle are not particularly efficient converters of grain into meat, it will be chiefly the price ratio of the two which will continue to dertemine the amount of grain fed to cattle. Politics and consumer behaviour will influence these prices and thus affect the volume of meat production. However, since nearly two thirds of the world's agricultural land is suitable only for forage production and since at least 75 percent of the world's beef production is based on feeds which would not be utilized directly by man, beef will continue to furnish a significant part of the world food supply (DeGraff, 1968; National Livestock and Meat Board, 1977). Even in the United States, the largest user of grains in livestock production, approximately three fourths of the feed units for beef production come from sources not suitable for human food (Wedin et al., *1975).*

The argument of low animal efficiency in converting feedgrain to meat is overemphasized by those contemporaries who would like to solve the world food problem by stopping the consumption of meat. This is an oversimplified solution to a complex society and world trade problem. Millions of hectares would be producing no food for human consumption if they were not harvested by cattle, sheep or other ruminants, which are capable of converting into high-quality food such nutrient sources as forage and non-protein nitrogen (NPN) and processing by-products of lesser usefulness. Even grains fall into this category when their prices are at a level permitting profitable meat production. Affluent societies will continue to raise by bidding the price of meat and thus make it possible for livestock to compete successfully for a portion of the world grain supply and land resources.

However, the continually growing human population will provide ever-increasing competition for grains and other crops edible by man and hence for all land capable of producing these crops. As this occurs, an increasingly greater portion of livestock production will have to come from pasture, forages, by-products, milling and wastes from processing of crops which can either be fed directly to livestock or with further processing can be made into animal feeds.

The amount of meat that will be eaten is greatly determined by the price the consumer is willing to pay and by the efficiency of livestock production. By improving the latter, the world food supply could be substantially increased.

The purpose of this article is to present results of research on maximizing beef production per hectare utilizing the maize crop, NPN and nutrient sources for which animals do not compete with man. Since stalks and leaves of the maize plant contain almost 50 percent of its nutrients, much of the emphasis of this research was directed toward utilization of the entire plant.

Materials and methods

Facilities used include a feeding centre with forty lots with a capacity of 8 to 12 cattle each. The experimental feeding was conducted by means of an automated belt feeding system. The rations were weighed and mixed at each feeding time. Feeds used were shelled maize (rolled or ground); maize silage of 30 to 35 percent dry

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matter (DM), chopped to 0.7 cm or less and stored in tower silos; soybean meal; urea and mineral supplements. Treatment of silages was done with either urea or ammonia mixed with molasses and minerals. Laboratories were available for complete analyses of feeds and rations.

The cattle used in the various trials were steer or heifer calves (180-230 kg) or yearling steers (300-350 kg). They were primarily Hereford, Angus, crosses of these breeds or crosses with Charolais. Holstein steers were used in some trials to compare performance of "choice" grade steers with "good" grade steers. Cattle were allotted at random by weight to experimental groups; each treatment was replicated. Most trials were ended when the cattle reached "choice" grade (estimated), although this varied with the objectives of the trial and type of cattle fed. Complete carcass data were obtained by official graders of the United States Department of Agriculture (USDA).

Feeding trials were carried out to compare performance on all-silage rations with that on rations composed of 60 percent maize silage and 40 percent shelled maize on a dry matter basis. This is essentially what is often referred to as "1 percent rations" in which the cattle are fed shelled maize at a daily rate equal to 1 percent of their body weight plus all the silage they will eat. All rations (except negative controls) were supplemented with protein to make them isonitrogenous. In feed cost comparisons silage prices included the higher harvesting costs plus fertilizer costs for nutrients removed in the stover portion of maize silage.

Another series of feeding trials was carried out to determine the effect of treating silage at harvest with either urea (as part of a mixture) or an ammonia solution. The urea mixture contained 17.2 percent feed grade urea, 8 percent sodium sulphate, 6 percent dicalcium phosphate, 5.2 percent trace minerals, 58.6 percent finely ground shelled maize and 5 percent molasses. The ammonia solution consisted of 55.1 percent molasses, 23 percent water and inert ingredients, 13.1 percent nitrogen, 6 percent sodium chloride, 0.8 percent calcium, 0.5 percent phosphorus, 0.9 percent sulphur and 0.6 percent trace minerals.

The last set of trials reported below is on cattle performance when supplemental protein came from fermented, ammoniated and condensed whey (FACW). The 700 000 tons of whey solids produced annually in the United States create a problem for the dairy industry. The high water content of whey makes its concentration and dehydration costly; its economic value as human food or animal feed is therefore generally low. Because of its high lactose content and resultant biological oxygen demand

(BOD), it cannot be disposed of within environmental quality standards without incurring excessive costs.

Regardless of the problem of whey disposal, cheese consumption and, consequently, whey production are increasing in the United States; production of whey solids could double (i.e., become 1.4 million tons) in the next 20 years. Therefore the dairy industry is searching for alternative methods of whey disposal which would be more economical than present waste disposal systems (Satterlee, 1975).

The FACW is the final fermentation product obtained by the lactic acid fermentation of cheese whey with *Lactobacillus* sp., the continuous neutralization of the lactic acid formed with anhydrous ammonia, and later concentration of the fermented liquor to approximately one eighth its original volume. This product (FACW) contains 50 percent crude protein equivalent; approximately 20 percent of this consists of microbial cells and albumen, and 80 percent derives from ammonium lactate. It is a tan liquid with the viscosity of S.A.E. 10 motor oil; it will not freeze at −18°C and remains stable at 54°C.

Fermentation of 100 kg of whey results in about 12 kg of FACW. The present production of whey in the United States is sufficient to produce more than 1 million tons of FACW, which in turn could provide all the supplemental nitrogen or protein required by more than 7 million head of fattening cattle.

Results

I. All-silage rations vs 60 percent silage and 40 percent shelled maize

A total of 17 experiments involving 1 214 cattle were carried out to compare feedlot performance of cattle fed an all-silage ration with those fed a ration consisting of 60 percent maize silage and 40 percent shelled maize. Within experiments all rations were isonitrogenous. Of these 17 experiments, 12 were with steer calves and 5 with yearling steers.

Steer calves fed the 60 percent silage rations (Table 1) gained more rapidly than those fed the all-silage ration, 1.1 kg/head/day *vs* 1.0 kg/head/day. There was no difference in efficiency of gain (kg feed per kg gain). Calves receiving 40 percent shelled maize in their ration were fatter (lower cutability) and graded higher (about one third of a grade) than the all-silage fed calves. One hectare of whole maize, harvested and fed as maize silage, would produce 60 percent more beef than if 60 percent were harvested and fed as silage, and 40 percent as shelled maize. Feed cost per kg of gain was approximately 14 percent less for the all-silage ration; however, this figure will vary with the relative prices placed on silage and shelled maize.

The same rations fed to yearling steers (Table 2) gave almost identical

TABLE 1. — **Comparison of two levels of maize silage on performance and cost of production of steer calves**
(12 trials, 914 cattle)

Ration	Av. daily gain	Feed	Carcass grade [1]	Cutability	Beef produced	Feed cost
	Kg	*DM/kg of gain*		*Percent*	*Kg/ha*	*$/kg gain* [2]
100% maize silage	1.0	6.9	10.8	50	2 053	0.25
60% silage, 40% shelled maize	1.1	6.7	12.2	49	1 278	0.29

[1] 10 = good; 13 = choice; 16 = prime. — [2] Maize silage (30% DM), $0.009/kg; shelled maize, $0.05/kg; and protein supplement, $0.10/kg.

IN BUNKER SILOS, PACKING IS NECESSARY FOR GOOD FERMENTATION

TABLE 2. — **Comparison of two levels of maize silage on performance and cost of production of yearling steers**

(5 trials, 300 cattle)

Ration	Av. daily gain	Feed	Carcass grade	Cutability	Beef produced	Feed cost [1]
	Kg	*DM/kg of gain*		*Percent*	*Kg/ha*	*$/kg gain*
100% maize silage	1.1	6.9	11.7	50	2 087	0.28
60% silage, 40% shelled maize	1.2	7.0	12.2	49	1 228	0.34

[1] Prices same as for Table 1.

TABLE 3. — **Performance of steers on an all-maize silage ration with and without NPN**

Silage treated with	Calves (4 trials)		Yearlings (2 trials)	
	Av. daily gain (kg)	Feed DM/kg gain	Av. daily gain (kg)	Feed DM/kg gain
Nothing (soy-mineral supplement)	0.9	7.4	1.1	6.8
Ammonia-mineral solution	0.9	7.0	1.0	6.9
Urea-mineral mixture	0.9	7.2	1.0	7.2

TABLE 4. — **Performance of steers on a ration of 60% maize silage and 40% shelled maize with and without NPN**

Silage treated with	Calves (4 trials)		Yearlings (2 trials)	
	Av. daily gain (kg)	Feed DM/kg gain	Av. daily gain (kg)	Feed DM/kg gain
Nothing (soy-mineral supplement)	1.1	6.5	1.2	6.8
Ammonia-mineral solution	1.1	6.0	1.3	6.6
Urea-mineral mixture	1.1	6.4	1.3	6.5

TABLE 5. — **FACW as nitrogen source in two types of maize-based rations for feedlot steer calves (16 per treatment)**

Treatment	Av. daily gain		Feed DM/kg gain	
	100% silage	60:40 Silage:shelled maize	100% silage	60:40 Silage:shelled maize
Negative control	0.51	1.00	11.1	7.8
FACW [1]	0.94	1.14	8.3	7.3
Urea [1]	0.95	1.13	8.3	7.5
Soybean meal [1]	1.02	1.15	8.1	7.4

[1] All treatments except negative control were isonitrogenous.

results, except for a slightly greater average daily gain from both rations. The steers fed the all-silage ration averaged 0.1 kg daily gain less, were equal in feed efficiency, graded slightly lower and had 1 percent higher cutability. On the basis of these results, using the entire maize crop as silage would result in the production of 70 percent more beef per hectare than if 60 percent were used as silage and 40 percent as grain. The feed cost per kg of gain was U.S.$0.06 or 18 percent less on the all-silage rations.

In summary, these trials indicated that feedlot cattle on an all-maize silage ration, compared with cattle on a ration of 60 percent maize silage and 40 percent shelled maize, will gain about 10 percent less rapidly and have slightly less marbling. However, they will carry slightly less fat and will be about equal in feed efficiency. Beef production per hectare will be increased by 60-70 percent if the entire crop is fed as maize silage. Feed cost per kg of gain will be from 14 to 18 percent less on all-silage rations.

II. Treating maize silage at harvest with an ammonia solution or a urea mixture

All-silage rations

In four separate trials involving a total of 194 steer calves, performance was approximately equal when silages were suppiemented with soybean meal and minerals or after treatment with either a solution of ammonia and minerals or a mixture of urea and minerals (Table 3). Calves on each treatment averaged 0.9 kg gain per day.

In two trials involving 52 yearling steers (Table 3) the group receiving the soybean meal supplement gained about 0.1 kg/day more than those fed either of the treated silages. Those fed the silage treated with urea and minerals were slightly less efficient in feed conversion than steers on the other two treatments.

Rations of 60 percent silage and 40 percent shelled maize

Steer calves gained equally when their protein requirements were met by

either a soybean meal supplement or by treating the silage with an ammonia solution or urea (Table 4). Those fed the silage treated with the ammonia solution required slightly less feed per unit of gain than steers on the other two treatments.

Average daily gain and feed conversion were about equal for yearling steers on the three different treatments (Table 4), with an average daily gain of 1.2 to 1.3 kg and an average of 6.5 to 6.8 kg feed DM per kg of gain.

On the basis of these 12 experiments utilizing 414 cattle, it appears that cattle growing and fattening on a maize silage-based ration perform almost as well with NPN additions to silage at harvest as with soybean meal as a supplementary source of nitrogen. With so little difference in performance, the choice of nitrogen supplement will be largely governed by the relative costs of supplements and the ease of incorporating them in rations. Figure 1 shows how much one can pay to treat silage with NPN and minerals *versus* feeding natural protein supplements in the ration.

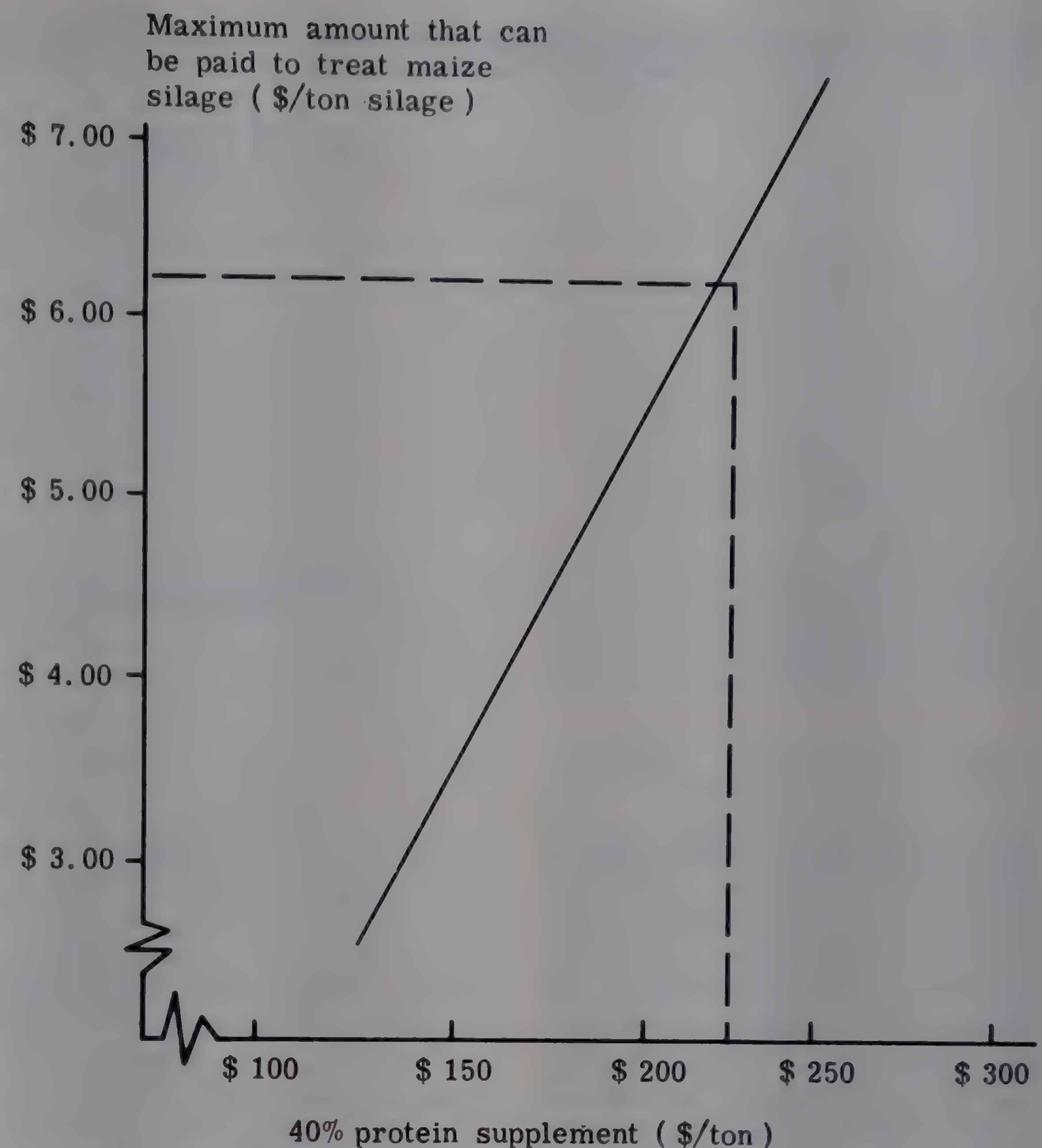

FIGURE 1. — *Maximum amount that can be paid to treat maize silage ($/ton silage) when compared to feeding natural protein supplements in the ration (based on $2.25/bu maize).*

III. FERMENTED, AMMONIATED AND CONDENSED WHEY (FACW)

Two trials were carried out to compare performance of cattle receiving as supplements FACW and urea or soybean meal. The comparisons were made both on an all-silage ration and on a ration of 60 percent silage and 40 percent shelled maize.

The average data for the two trials are shown in Table 5. All treatments were superior to the negative controls concerning both rate of gain and feed conversion. Calves on the FACW-supplemented rations performed as well as those receiving soybean meal or urea instead. An interesting point is that the negative control group which received shelled maize performed more closely to the protein supplement groups than did the negative control group receiving the all-silage ration.

These results demostrate that by-products from food processing can be used for cattle feeding with good results and also that in ruminant feeding considerable savings in protein may be made through its substitution by NPN. In order for the latter to become a widely accepted practice, the NPN sources must be available at somewhat lower prices than those of the more traditional sources of supplementary protein. ■

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The development of artificial insemination in Iraq

F.I. El Dessouky

Iraq is well endowed with both oil and water resources and extends more than 1 000 km from north to south, having a total land area of 174 million donums (1 donum = 2 500 m²). Of the 48 million donums of cultivable land, less than 13 million are used for cultivation; a further 10 million donums are saline and can be reclaimed for cropping.

Climatic conditions in Iraq are severe, the summer being extremely hot with mean shade temperatures in August of 34.8°C and mean maximum and minimum temperatures of 43.5 and 24.7°C. The relative humidity is high in the south, but low in the central and northern zones. The winters are cold. Rainfall is scanty and erratic except in the northeast where about 500 mm fall, mainly in winter.

The population is about 10 million, increasing at a rate of 3.1 percent per annum. The 1974 livestock census showed that there were about 2 million cattle, 195 000 buffaloes, 8.4 million sheep, 1.95 million goats and 68 000 camels. The annual increase in animal production is only 2.2 percent. The per caput annual consumption of meat and milk averages 15 kg and 33.2 kg respectively.

Cattle contribute practically 50 percent of the meat and milk produced in the country, which amounted to some 55 800 tons of meat and 165 000 tons of milk in 1974. As in most developing countries, the productivity and breeding efficiency of native cattle are extremely low. There are four groups of native cattle (Genubi, Sharabi, Kurdi and the nondescript local), and very little information on performance is available. The milk production of the Genubi cows ranges from 800 to 1 000 kg per lactation on government farms, while less than half this amount is produced in local herds. Dessouky *et al.* (1975), reported the daily gain for the Genubi and Kurdi breeds to be 558 g and 576 g respectively.

Breeding methods

Selective breeding within local cattle is too slow to ensure a sufficient rate of genetic improvement for increased milk production. Since 1942, therefore, the policy has been to crossbreed the low-producing local animals using Friesian bulls. The use of the Friesian is justified because of its higher dairy and meat production potential, and also because of its adaptability to differing environmental conditions. The improvement of the local cattle through crossing and subsequent upgrading with the Friesian breed is based on three main considerations:

- Friesians are the best imported exotic breed for milk and meat production;
- Crossbred cattle adapt well to the local climate, prevailing diseases and parasites;
- Both pure Friesians and their crosses surpass the local cattle in milk and meat production (Asker *et al.* [1965], and Dessouky *et al.* [1975]; Table 1).

As long ago as 1945 the Government was making young Friesian bulls available to cattle owners for crossbreeding. In 1962 A.I. was adopted as a more efficient means of implementing the breeding policy, and 648 inseminations were carried out during that year; these increased markedly, reaching 132 399 inseminations in 1976. In the beginning, conservative Iraqi farmers were suspicious of the new technique. Their participation was encouraged by the A.I. service which provides sexual health control, including veterinary treatment at calving and during the puerperal period, if required. Successful treatment of infertility cases, higher milk yields, and the early maturity and higher fertility rates

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of the Friesian crosses have helped to convince breeders of the usefulness of the programme.

With the spread of A.I., the bull distribution scheme was terminated in 1969, though a few centres still retained bulls for natural service in areas where A.I. was difficult or impossible to organize without frozen semen. Most of the Friesian bulls used in these centres have since died, mainly from theileriosis, and will now be replaced by A.I. centres using frozen semen.

TABLE 1. — **Production performance of Iraqi native cattle**

Trait		N [1]	X [2]	C.V. [3]
Age at first calving	(months)	39	44.9	45
Service period	(days)	130	103.0	73
Calving interval	(days)	121	396.0	27
305-day milk yield	(kg)	99	1 027.0	57
Dry period	(days)	93	182.0	57
Lactation period	(days)	99	219.0	35

SOURCE: Asker *et al.*, 1965.

[1] N = number of observations. — [2] X = mean. — [3] C.V. = coefficient of variation (percent).

A.I. organization

Each province in Iraq has at least one main A.I. centre. This centre forms a nucleus for the A I. scheme and sexual health control services; these services are further extended through a network of sub-centres. At present there are 20 main A.I. centres, including that at Abu-Ghraib where the A.I. Division of the Directorate-General, Animal Resources, is located, and an additional 135 sub-centres spread throughout the country. Each main centre is a self-contained unit; it has a well-equipped laboratory and sheds for two to four purebred Friesian bulls; the Abu-Ghraib A.I. centre has about 32 bulls and a training section. Semen is collected twice a week at the main centres where it is evaluated and processed. From these centres semen is dispatched on the day of collection in thermos flasks at 5°C to 6 to 10 sub-centres. Skimmed milk with 10 percent egg yolk and antibiotics is used as a diluter. The diluted semen is dispensed into sterilized glass vials of 10 to 20 ml capacity and transported to the sub-centres in polystyrene boxes with ice. Each sub-centre has a refrigerator for preserving diluted semen and a microscope for assessing motility.

Lay-inseminators travel daily to a number of crushes at a prearranged time. The average distance between crushes is about 2 km and inseminations, pregnancy checks and infertility treatment are carried out at these points without charge. A farm visit service is provided when feasible. There are now 110 cars, 150 motorcycles and three motorboats to cover the different villages with A.I. service. The recto-vaginal technique of insemination is practised, using disposable plastic catheters. The inseminated cow is usually checked for pregnancy 60 days after insemination. Cows are given treatment if they do not conceive after the third insemination, antibiotics, hormones and other specific therapy being used.

During 1975, 23 058 cows and buffaloes were examined and treated for sexual disorders; 26.1 percent were found pregnant, while the percentages of inactive ovaries, uterine problems, retention of placenta, persistent *corpus luteum* and cystic ovaries were 19.2, 12.2, 5.2, 4.1 and 1.9 respectively.

Surveys for brucellosis are undertaken by A.I. veterinarians, and steps are being taken to survey venereal diseases such as vibriosis and trichomoniasis and to establish a research institute for female and male infertility.

Recording. To judge the efficiency of the programme the maintenance of proper records is essential. The recording system should also provide data for any future modification of the service. The first copy of the record form is intended for the use of the owner, a second copy being retained by the inseminator for central analysis. These records include all the information about the inseminated cow, number, date and time of inseminations, name of the bull and the inseminator, in addition to the sexual health status of the inseminated animal. Results of the conception rate

FIGURE 1. — *Bullshed in a main A.I. centre*

per bull, per inseminator and per province are also compiled. Twenty percent or more of the cows are chosen at random for this purpose. Non-return rates are not calculated.

Results in 1976 can be summarized as follows:

Total number of inseminations	132 399
Number of cows checked for pregnancy	20 866
Percentage of cows pregnant to first insemination	56.6
Percentage of cows pregnant after two inseminations	66.0
Number of inseminations per inseminator per year	877

FIGURE 2. — *Crushes where daily A.I. service and infertility examinations are carried out*

Frozen semen. Since 1976 frozen semen has been used in the A.I. programme, gradually replacing liquid semen, especially in Baghdad and the northern areas. Semen is collected from imported proven Holstein and European Friesian bulls at the Abu-Ghraib A.I. centre and is processed by freezing it in liquid nitrogen, using Laciphos 270 as a diluent. Ministraws are used and are filled and sealed mechanically. As liquid nitrogen is not commercially available in the country, cryogenic plants were installed in Baghdad with a capacity of 36 litres an hour. Four small machines (6 litres an hour capacity) will be installed in Mosul, Kurkuk, Diwanyah and Basrah in the near future.

Training. Because of the need for more personnel to cover increasing demands, training facilities for both veterinarians and technicians in A.I. were arranged at the Abu-Ghraib A.I. centre. In addition to the theoretical courses in A.I. and animal husbandry, practical training on government farms is provided and the animals at the White Gold Colony and at slaughterhouses in Baghdad are also used in the training course. The course for technicians lasts for three months and all students are provided with a textbook on A.I. in Arabic. Some students have been sent for training in France, the United Kingdom, Austria, the Netherlands, the Federal Republic of Germany, Hungary and Egypt.

During the first months of practical work for the trainees, supervision is exercised by senior inseminators, until they gain the necessary practical skill and show sufficiently good technical results.

FIGURE 3. — *Lay-inseminators in their daily work*

Problems. Major problems encountered in the development of A.I. in Iraq are summarized below:

- There is a great demand for A.I. services and development has been rapid, but the shortage of trained personnel makes the programme difficult to implement. Training programmes for both veterinarians and lay-inseminators are helping, and refresher courses are also arranged, both at Abu-Ghraib and abroad, to improve the efficiency of A.I. staff.

- When A.I. was introduced, some farmers were not convinced of its usefulness and had doubts on both social and religious grounds. Other constraints were the lack of veterinary and extension services; irregular marketing policy and facilities; and shortage of animal production support projects.

The provision of good exotic bulls for natural service for the production of higher yielding crossbreds helped to convince small farmers of the economic benefits of an improved breeding programme. In addition, the successful treatment of infertility cases and higher conception rates have also helped to convince farmers of the value of the A.I. service.

- In the early days of the scheme, poor road communications were obstacles to expansion of the A.I. service. Since then, road improvements, increasing the number of motorized inseminators, together with the number of sub-centres and insemination points, have all helped to expand the programme.

- The deterioration of semen quality in a considerable number of bulls, especially in centres where animals were not protected against the severe effects of high summer temperatures, affected the progress and success of the programme in this season (Dessouky and Juma, 1968; Rollinson *et al.*, 1969). Replacing liquid semen with frozen semen collected and processed in the less severe seasons will help to solve this problem.

- There is considerable loss of liquid nitrogen through evaporation during transport in cryogenic containers and tankers, especially in the hot dry summer season. Investigations are being carried out to find the most suitable container for field work under these conditions. Increasing the chain of liquid nitrogen plants will reduce the distances mobile tankers have to travel and will reduce this loss.

FIGURE 4. — *Field A.I. recording system*

- A very high incidence of theileriosis was reported (Yossif, 1969) in imported Friesians, and sometimes drastic losses in semen production were observed. Therefore, during the critical season all bulls are regularly sprayed against ticks, and their temperatures are recorded daily.

Economic aspects. The costs of an A.I. service depend mainly on cattle density and the number of cows served. In the earlier stages of the project, the cost per cow was very high and even now it varies widely among provinces and centres, depending on: the number of sub-centres and services; the response of breeders to the programme; livestock marketing conditions; ease of communication; and the concentration of animals. As men-

FIGURE 5. — *Semen collection in main A.I. centre*

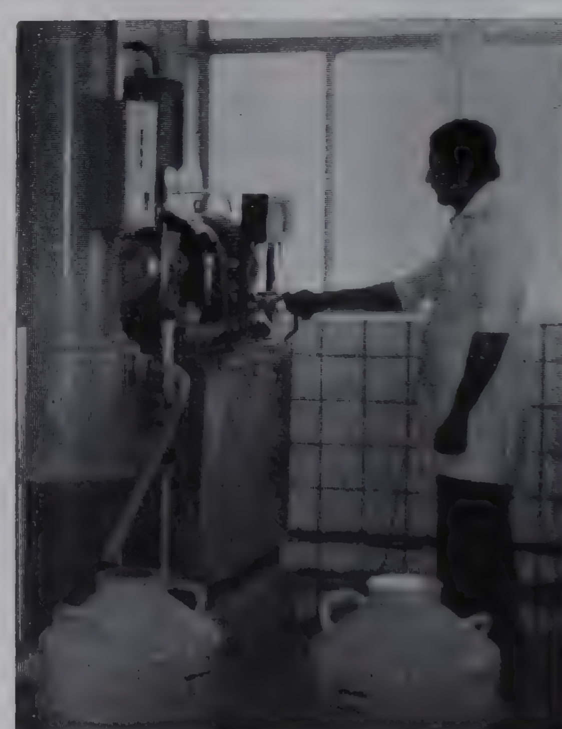

FIGURE 6. — *Semen evaluation in main A.I. centre.*

TABLE 2. — **Production characteristics of crosses of Iraqi native cattle (Genubi) with Friesian**

Grade type		Age at first calving	305-day milk yield	Lactation period	Service period	Dry period	Calving interval
		Months	*Kg*	. . . .	*Days*	. . . .	
1/2 F	N [1]	86	310	310	232	204	216
	X [2]	35.7	2 192	319	179	153	477
	C.V. [3]	21	39	37	85	84	32
3/4 F	N	87	202	202	158	147	152
	X	39.7	2 316	323	231	180	518
	C.V.	24	46	38	68	85	28
7/8 F and over	N	62	113	113	115	97	99
	X	38.5	2 475	328	187	140	467
	C.V.	26	31	28	74	98	25

[1] N = number of observations. — [2] X = mean. — [3] C.V. = coefficient of variation (percent).

tioned, all A.I. services are provided to farmers free of charge, but the costs of A.I. per cow in each main A.I. centre are calculated every year. As an example, the figures for 1976 were Iraqi dinars 2.165 and 3.408 (U.S.$7.34 and 11.55) in the Babylon and Mosul A.I. centres respectively. The major expenses of an A.I. breeding service are represented by the wages of personnel which, in many cases, amount to over 75 percent of the total variable costs. However, it should be pointed out that the cost of running A.I. centres will show a return in the form of increased milk and meat production.

The future of the breeding plan and A.I. service

The beneficial effects of A.I. are clearly revealed by the fact that the number of crossbred cows of various grades in 1972 was estimated at 100 000 head, or five percent of the cattle population. Taking into consideration the ever-growing efficiency of the A.I. centres and the increasing rate of production of crossbred animals, it can be safely said that a tangible change in the genetic structure of the national herd has already taken place and is continuing. As far as milk and meat production are concerned, farmers already know that their crossbreds are far more productive than native cattle and they are now raising their crossbreds by using better feeding and management practices. Marketing channels are also now available to them.

Results of research show that increasing Friesian blood to 75 percent or more does not significantly increase milk production. On the other hand, there was a decrease in reproductive efficiency in the higher crosses (Table 2).

It is therefore concluded that:

- unselected ½-bred, ¾-bred or other grades of unselected Friesian bulls should be used in areas not covered by an A.I. service with the object of producing females having some *Bos taurus* blood to form a pool of breeding material for subsequent breeding by A.I. when the service is introduced;

- inter-se matings of ½-bred and ¾-bred cattle should be undertaken at livestock research stations under a progeny testing programme for increasing milk production. To facilitate a bull testing programme it is necessary to establish a systematic recording service and a breeding record analysis unit.

One last important point is that an A.I. service is a comparatively sophisticated tool in animal husbandry. It will not fulfil its aims of increasing production unless it is linked with a constructive scheme introducing reasonable standards of animal nutrition, disease control and animal husbandry extension. There must also be sufficient economic incentive to encourage producers to adopt improved standards. The recent policy which tends to gather farmers into types of cooperative and collective farms will greatly assist in the improvement of these aims and of the national herd. ■

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Barbados Blackbelly sheep

J.P. Maule

The Barbados Blackbelly sheep (*B. Barriga Negra*), as its name implies, has a distinctive appearance. Its coat of hair is reddish brown, though this can vary from light to dark brown, with black points on the face (round the eyes, mouth and throat), black ears, and often a black patch or spot above the eyes. The underside of the belly is entirely black, as is also the lower part of the legs. Rams have a characteristic mane extending from the neck to the brisket, and both sexes are hornless. Blackbelly sheep are of medium size; adult rams have a withers height of 60 to 65 cm and weigh from 50 to 70 kg, while ewes weigh from 32 to 43 kg.

The breed's most important characteristic is the prolificacy of the ewes. Breeding occurs throughout the year and multiple births are frequent, usually being twins or triplets. Even larger litters have been recorded; there was one case of quintuplets in a ewe imported into the United States in 1940, and in 1970 eight lambs were reported to have been produced in one litter by a ewe in Barbados (K. Laurie, undated personal communication), though it is not recorded how many were reared. Ewes are said to be able to rear up to four lambs without supplementary feeding.

This prolificacy is the reverse of nearly all breeds of tropical sheep, for which one lamb per pregnancy is usual. Occasionally twins have been reported in African sheep but rarely in Indian breeds. It is all the more surprising when the supposed origin of the Blackbelly sheep is taken into account. It has been suggested (Devendra, 1972) that it and another red or white woolless breed, known as West African, came originally from the west coast of Africa either direct to Barbados or via Brazil, where the Brazilian woolless breed (Deslanado do Nordeste or Deslanado Vermelho) has been established for a long time. Some evidence of a west African origin is supplied by Epstein (1971) who describes a sheep of similar appearance to the Blackbelly found in Cameroon.

BARBADOS BLACKBELLY EWE (FOREGROUND) PHOTO: C.A.B.

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TABLE 1. **Lambing and mortality data for three breeds at Maracay, Venezuela**

Breed	Number of ewes lambed	Number of lambs born	Lambs born/ewe	Multiple births	Mortality: Birth to weaning	Mortality: Weaning to 6 months	Mortality: Total	Proportion of lambs surviving at 6 months
				Percent				
Barbados Blackbelly	195	282	1.45	39.0	19.1	15.4	34.5	65.5
West African	277	396	1.43	41.2	15.8	9.9	25.7	74.3
Criollo	227	257	1.13	12.3	10.8	10.0	20.8	79.2

Source: Bodisco *et al.*, 1973.

He also describes a dwarf type of brown sheep with a black belly in the upper Congo basin.

In a short account of the breed Laurie suggests that "up to the end of the slave trade in 1838, several breeds of west African sheep were brought to the West Indies in slave ships, and some crossing must have occurred with the European breeds which came with the first colonists, with natural selection favouring the hair sheep". One might add that in all probability the breeders themselves would have tended to retain for breeding the better adapted hair sheep in preference to the wool variety.

Whatever their origin, these hair sheep are remarkably hardy and have become completely adapted to the West Indian environment and to the small-scale farming common in Barbados and the other islands. In Barbados there are about 30 000 Blackbelly sheep, 80 percent of which are kept in flocks of only 5 to 10 sheep. They are grazed on the edges of cultivated land and on any rocky uncultivated ground. A Barbados Sheep Farmers' Association with about 50 members has recently been set up but has yet to be recognized by the Government, which has imposed a ban on all exports of these sheep (Rastogi, 1975).

Blackbelly sheep do well in Tobago, and there are also small numbers in several other islands including Grenada, Antigua, St. Lucia and St. Kitts. An important source of information is the flock established some years ago at the Centro Nacional de Investigaciones Agropecuarias at Maracay, Venezuela.

Blackbelly sheep were imported into the United States in July 1904 when four ewes and one ram were received in Bethesda, Maryland, the intention being to send them further south. A flock was established at North Carolina State University, where Professor Lemuel Goode has crossed this breed with Polled Dorset as part of a crossbreeding programme using Finnish Landrace and Rambouillet sheep, and another, it is believed, at Texas A and M University.

Although Goode reports favourably on their hardiness (less than 10 percent lamb mortality), fertility and prolificacy (about 180 percent lamb crop), he considers the Blackbelly sheep to be too small and to grow too slowly to be of much use as purebreds. He also comments on their nervous disposition, stating that they do not take kindly to being turned loose in a field, presumably because they are accustomed to being herded in small numbers (Goode and Tugman, 1975).

Reproductive performance. Apart from the statement that Blackbelly sheep are known to be very prolific, little information on litter size has been published, the most detailed being that of Bodisco (*et al.*, 1973) at Maracay, where the performance of the Blackbelly sheep has been compared with that of West African and local Criollo breeds. The data for the period 1968 to 1972 (summarized in Table 1) do not give the total number of breeding ewes of each breed, so that lambing percentages cannot be calculated; but from the number of lambs born per ewe, lambing was found to be almost identical for the Blackbelly and West African ewes (1.45 and 1.43 respectively).

The proportion of multiple births was practically the same for both breeds, being 39.0 percent for Blackbelly and 41.2 percent for West African. Criollo ewes had only 12.3 percent.

Lamb mortality up to weaning was

TABLE 2. **Mean live weights of three breeds of sheep from birth to six months**

Breed	Birth weight	Weaning weight	6 months weight	Weight of lambs produced per ewe at 6 months	L.W.G. per day to 6 months
	Kilograms				*Grams*
West African	2.78	12.47	18.22	17.04	77
Barbados Blackbelly	2.54	12.13	20.45	17.13	90
Criollo	2.76	12.06	16.36	12.96	66
Mean	2.70	12.25	18.26	15.04	77

Source: Bodisco *et al.*, 1973.

TABLE 3. **Summary of lambing and re-breeding performance at Upper Mountain Research Station** [1]

Ewe cross	1st lamb crop February, 1974			2nd lamb crop October, 1974			3rd lamb crop March, 1975			Total lambs sold
	Lambing	Lambs born per ewe	Lambs surviving at 30 days	Lambing	Lambs born per ewe	Lambs surviving at 30 days	Lambing	Lambs born per ewe	Lambs surviving at 30 days	
	Percent			*Percent*			*Percent*			
Dorset × B. Blackbelly	100	1.87	1.80	93.8	1.75	1.56	93.8	1.94	1.75	4.91
Dorset × F. Landrace	100	2.13	1.93	87.5	1.62	1.56	93.8	2.25	1.69	4.96
Rambouillet × F. Landrace	100	2.46	2.06	62.5	1.12	1.00	75.0	1.69	1.56	4.56

Source: Goode and Tugman, 1975. — [1] Laurel Springs, North Carolina.

higher for Blackbelly lambs (19.1 percent) than for West African lambs (15.8 percent) or Criollo (10.8 percent). From weaning to six months of age it was again highest for the Blackbelly lambs, as one would expect; mortality in all three breeds was higher among twins and triplets than among singles, being 21.6 percent for the last compared with 32.4 for twins and 36.7 for triplets.

From these data it was possible to calculate the proportion of lambs of each breed surviving to six months (see Table 1); in this respect the Blackbelly sheep compare unfavourably with both the West African and Criollo.

Devendra (1977) quotes data from Guyana which are very close to those given above. In one 3-month lambing season in 1976, litter size of 168 lambings averaged 1.46 with 41.4 percent single births, 48.3 percent twin births and 10.3 percent triplets.

Frequency of lambing. One of the characteristics of most tropical sheep is their ability to breed throughout the year, or to have more than one breeding season. Because of this some breeders have attempted to breed their ewes so that they will lamb three times in two years at intervals of approximately eight months. The only data available on this are for crossbred ewes in North Carolina, where Dorset × Blackbelly ewes which were mated in September and October 1973 lambed in February 1974, were re-mated in April and May 1974 to lamb for the second time in September and October 1974, and finally were again mated in October and November to lamb for the third time in March and April 1975: three lambings in 18 months. The results are given in Table 3.

In Venezuela three lamb crops were obtained in 25 months with West African sheep (Garcia *et al.*, 1974), but unfortunately no data are given for these or any information given for Blackbelly ewes.

Information given to the author by a private breeder of Blackbelly sheep in Grenada showed that a small group of ewes averaged 5.6 lambings in four years (1971 to 1974), equivalent to an interval between lambings of eight months. Litter size averaged 2, and the ewes produced 2.85 lambs per year. The breeder found that to obtain litters of more than one or two lambs it was imperative to give the ewes some such supplementary feed as grain, since otherwise not only were the litters small but the lambs were weak.

Growth. There are very few data on the growth and meat production of Blackbelly sheep, and what there are come from the work at Maracay with the Blackbelly, West African and Criollo sheep. These are summarized in Table 2, from which it can be seen that, whereas there is little difference in live weight between the three breeds up to weaning, from then until the lambs are six months of age the Blackbelly lambs grew much faster than the other two breeds and had the highest average daily gain of 90 g from weaning. In terms of weight of lamb produced per ewe at six months, the Blackbelly was slightly superior to the West African.

Devendra (1970) quotes a figure for daily liveweight gain of 130 to 180 g and adds that "evidence at the University of West Indies Field Station indicates that the Barbados Blackbelly responds well to fattening on high energy supplementary diets", but no data in support of this were given. However, his statement is borne out by work at Maracay (Chacon *et al.*, 1968), in which small numbers of Blackbelly, West African and Criollo sheep and crosses between Criollo and the other two breeds were fed for 94 days from approximately eight months of age when they weighed 20 kg. Average daily gain in the five groups was from 138 g for Criollo × West African castrates to 154 g for West African ram lambs and castrates. Blackbelly ram lambs and castrates averaged 148 g/day and Criollo × Blackbelly 152 g/day, but these differences were not significant. Dressing percentage averaged 44.

It is perhaps worth quoting from a report by W.R. Buttenshaw (1904) which stated that "sheep were usually sold at about 12 months of age when they weighed 90 lbs (41 kg) and had a dressing percentage of 50 to 55". Most sheep were fed on grass, supplemented occasionally with sweet potatoes. Well-fed wethers, however, weighed from 55 to 60 kg at 15 months. He also reported that ewes had no difficulty in rearing two to three lambs provided they were given some extra feed.

Performance of crossbred Blackbelly sheep. Crosses between Dorset and Blackbelly and between Dorset and Finnish Landrace have been made at two research stations (Raleigh and

CROSSBRED WILTSHIRE HORN MALE × BARBADOS BLACKBELLY EWE PHOTO: C.A.B.

Laurel Springs) in North Carolina in an attempt to improve overall productivity and profitability of lamb production. The two Dorset crosses have been compared with purebred Dorsets and Rambouillet × Finnish Landrace at Raleigh, and with grade Suffolks and Rambouillet × Finnish Landrace at Laurel Springs. The Landrace is, like the Blackbelly, noted for its prolificacy. The results at Raleigh showed that:

- Dorset × Blackbelly crosses lambed earlier than Landrace crosses and were more resistant to parasites than other ewe groups;
- in birth weight and survival to 30 days the lambs out of Dorset × Blackbelly ewes were superior to lambs out of Dorset and Dorset × Landrace ewes:
- at their second lambing Dorset × Blackbelly ewes averaged 1.7 lambs per ewe mated *vs.* 1.0 for Dorset and Dorset × Landrace and 2.1 for Rambouillet × Landrace;
- there was little difference in postweaning gain between lambs of the three crossbred ewe groups (0.29 kg/day).

The lambing results at Laurel Springs are summarized in Table 3. They show that similar groups of crossbred ewes to those at Raleigh could be re-bred while still lactating, and that it was possible to obtain three lamb crops within 24 months. In the first lamb crop the Rambouillet × Landrace ewes mated to Suffolk rams averaged 2.46 *vs.* 1.87 lambs for Dorset × Blackbelly ewes, but over three lamb crops the latter had a higher survival rate. The number of lambs sold per ewe for the first two lamb crops plus the number alive at 30 days for the third were:

Dorset × Blackbelly	4.92
Dorset × Landrace	4.86
Rambouillet × Landrace .	4.56

However, whether the differences in favour of the Dorset × Blackbelly were significant is not stated.

There was little difference between the three crossbred ewe groups in average daily gains of lambs or in weight when marketed for slaughter:

44.5 kg for Dorset × Blackbelly, 45.0 for Dorset × Landrace, and 45.2 for Rambouillet × Landrace.

Goode comments on these trials that crossbred Dorset × Blackbelly ewes may be suitable in a breeding programme to obtain three lamb crops in two years without early weaning of the lambs, and that such a programme would reduce the amount of concentrates required for finishing the lambs.

Conclusions and future prospects.

It is clear that there are few data on the performance of Blackbelly sheep in the West Indies. What data there are (from Venezuela) suggest that, when managed as a flock rather than a small group, ewes may not be as prolific as has been claimed and are not noticeably superior in this respect to the West African sheep, which are not unlike the Blackbelly in appearance as well as performance. There is no mention of the possible role of either of these breeds for increasing mutton production, although they seem to be well adapted to the small-scale farming which is characteristic of West Indian agriculture.

However, at the First Regional Livestock Meeting held in Trinidad in September 1975, Dr. Rastogi outlined a performance recording scheme to obtain accurate information on the more important economic traits in Blackbelly sheep in Barbados. These traits are:

- lambing percentage, i.e. the proportion of ewes that lambed after being put to the ram;
- lambs born per ewe that lambed;
- lambs weaned per ewe in flock and per ewe lambed;
- daily gain in weight to weaning (including weight at weaning);
- daily gain in weight from weaning to slaughter.

These data are the minimum required if the overall performance of the breed is to be accurately assessed and, later, improved.

One aspect of the Blackbelly sheep's performance is high lamb mortality; the Maracay data pinpoint this problem very clearly, showing that only 65 percent of Blackbelly lambs born were reared to six months of age. Lamb mortality is likely to be higher in ewes with more than two lambs than in ewes with one or two strong lambs; at Maracay lamb losses among triplets averaged 36.7 percent, compared with 21.6 percent for single lambs. Thus, it is of particular importance to know the proportion of lambs weaned per ewe.

Rastogi also advocated the development of an improved breed to combine the fertility and prolificacy of the Blackbelly with the growth and carcass characteristics of an introduced mutton breed; as a short-term measure he proposed a commercial crossbreeding programme in which all the crossbred lambs would be marketed, but he made no suggestion as to the choice of sire breed. A crossbreeding programme on these lines was started in the 1950s using Wiltshire Horn rams, but it petered out without leaving much, if any, trace of Wiltshire Horn blood. The author does not believe that a project of this kind would be successful in Barbados at the present time. It would be better to select from among the existing purebred sheep for better growth rate and conformation, but until some accurate information on these characteristics is obtained it is not possible to know whether faster growing strains exist or not.

On the other hand, the Blackbelly sheep might well be used for crossing with mutton breeds, such as Dorset Horn, in environments where parasite problems and heat stress are not limiting factors. This might well be investigated experimentally in the West Indies where Blackbelly sheep are available, as unfortunately the ban on exports of these sheep from Barbados prohibits any experimental breeding programme being undertaken in countries which do not already have some of these sheep.

With regard to the mutton breeds most likely to make a good cross, it is worth citing Buttenshaw's report again. He quotes E.M. de Freitas of Grenada who had used Hampshire, Shropshire and Southdown rams to grade up his "African" hair sheep and found that the Southdown was by far the best; in fact, he described the cross as "a handsome sheep", resembling its sire but hardier than either parent.

In conclusion, one is bound to re-emphasize the paucity of information on the performance of the Barbados Blackbelly both as a purebred and in crosses with the Criollo in South America and with the Persian Blackhead in the West Indies. It is to be hoped that interest in the preservation of the breed in Barbados and in the implementation of performance testing will establish the breed's credentials as a useful mutton breed, not only in the West Indies but also on the neighbouring mainland. ■

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Trace mineral nutrition in Latin America

Lee R. McDowell and Joe H. Conrad

The incidence and significance of livestock trace mineral deficiencies and toxicities in Latin America are described briefly, together with appropriate detection techniques and preventive methods. Inadequate trace mineral nutrition is obviously limiting livestock production in Latin America. Although provision of mineral supplements to grazing ruminants is more complicated than for monogastric livestock, mineral supplementation represents low input/high output nutrients for greatly increasing livestock production; indeed, no single factor has as much potential to increase Latin-American livestock production at low-cost input as adequate mineral nutrition.

Throughout Latin America nutritional disorders account for a major segment of the factors limiting productivity of livestock. Wasting diseases, loss of hair, depigmented hair, skin disorders, non-infectious abortion, diarrhoea, anaemia, loss of appetite, bone abnormalities, tetany, low fertility and pica are clinical signs often suggestive of mineral deficiencies throughout the world. The extent to which a lack of sufficient energy and protein is responsible for these clinical signs is still largely unanswered. However, numerous investigators have observed that livestock sometimes deteriorate in spite of an apparent adequate feed supply (Sutmöller *et al.*, 1966). Ruminants grazing forages in a severe cobalt (Co)- or copper (Cu)-deficient area are even more limited by lack of these elements than either that of energy or protein.

Seven trace elements are generally accepted as essential for livestock, including Co, Cu, iodine (I), iron (Fe), manganese (Mn), selenium (Se) and zinc (Zn). In specific areas toxic concentrations of Cu, fluorine (F), Mn, molybdenum (Mo) or Se limit livestock production. The significance of additional toxic elements (arsenic, lead, cadmium, mercury and aluminium) as well as the "newer" trace elements, chromium, fluorine, vanadium, molybdenum, nickel, silicon and tin, have been reviewed (Underwood, 1977).

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Underwood (1977) presents a comprehensive description of the many diverse functions of trace minerals as well as specific clinical signs of deficiencies or toxicities. This review will emphasize the incidence and significance of trace mineral deficiencies and toxicities in Latin America and methods for their detection and prevention.

Factors influencing mineral requirements. Trace mineral recommendations and toxicities for selected classes of livestock are presented in Table 1. Many factors affect mineral requirements, including nature and level of production, age, level and chemical form of elements, interrelationship with other nutrients, mineral intake, breed and animal adaptation.

The trend toward complete confinement and absence of pastures for poultry and pigs has greatly increased the incidence of trace mineral and other nutrient deficiencies. Improved management practices that lead to improved production and growth rates for livestock and poultry necessitate more attention to trace mineral nutrition.

On the basis of low mineral concentrations in tropical forages during the dry season, it is logical to assume that grazing livestock would most likely suffer mineral inadequacies during this time. On the contrary, many world reports, including those of Brazil, Kenya and the Republic of South Africa, have noted specific mineral deficiencies more prevalent during the wet season (McDowell, 1976). During the wet season livestock gain weight rapidly since energy and protein supplies are adequate, and thus mineral requirements are high. However, during the dry season, inadequate protein and energy result in animals losing weight, which lowers mineral requirements.

Factors affecting plant mineral content. The concentration of mineral elements in plants from diverse regions in Latin America is dependent upon the interaction of a number of factors including soil, plant species, stage of maturity, yield, pasture management and climate. Most naturally occurring mineral deficiencies in livestock are associated with specific regions and are directly related to soil characteristics.

Sources of minerals for livestock. A large percentage of livestock producers in Latin America do not give their livestock supplemental minerals, with the possible exception of salt. Grazing livestock must therefore depend largely upon forages which only rarely can satisfy completely each of the mineral requirements for grazing animals. Table 2 summarizes the mineral concentrations of 2 615 Latin American forages (McDowell *et al.*, 1974). Borderline or deficient levels of certain elements were noted for many entries: Co, 43 percent; Cu, 47 percent; magnesium (Mg), 35 percent; phosphorus (P), 73 percent; so-

dium (Na), 60 percent; and Zn, 75 percent.

Grazing livestock obtain part of their mineral supply from sources other than forages, particularly from water and soil. Peak soil ingestion is favoured by soils with a weak structure and poor drainage, by high stocking rates, by high earthworm populations, and during the dry season when pasture growth is poor. In New Zealand annual ingestion of soil can reach 75 kg for sheep and 600 kg for dairy animals (Healy, 1974). Direct consumption of large quantities of soil (Figure 1) or bones (Figure 2) is often an indication of a mineral deficiency.

Mineral deficiencies and toxicities in Latin America. Mineral deficiencies or excesses in livestock are found and reported to some extent from almost all regions of the world. Table 3 combines recent reviews on the reported incidence of mineral deficiencies or toxicities in Latin America

TABLE 1. — **Suggested mineral requirements and toxicities for selected livestock and poultry (dry basis)**

	Growing and finishing steers and heifers [1]	Lactating dairy cows [2]	Sheep [3]	Pigs [4]	Starting chicks (0-8 weeks) [5]
Required elements					
Co, ppm	0.05-0.1	0.1	0.1	—	—
Cu, ppm	4	10	5	6	4
I, ppm	0.05-0.1	0.6	0.10-0.8	0.2	0.35
Fe, ppm	10	100	30-50	80	80
Mn, ppm	1-10	20	20-40	20	55
Mo, ppm	—	—	>0.5	—	—
Se, ppm	0.05-0.1	0.1	0.1	0.1	0.1
Zn, ppm	10-30	40	35-50	50	50
Toxic elements					
Cu, ppm	—	100	8-25	300-500	1 270
F, ppm	30-100	40	60-200	—	500-1 000
Mo, ppm	—	6	5-20	—	200-500
Se, ppm	5	5	>2	5-8	10

[1] N.R.C. (1976). — [2] N.R.C. (1971b). — [3] N.R.C. (1975). — [4] N.R.C. (1973). — [5] N.R.C. (1971a).

TABLE 2. — **Mineral breakdown and concentrations of 2 615 Latin American forages (dry basis)** [1]

Element	Percentage of forages with entries [2]	Number of entries	Requirement [3]			
Ca	42.9	1 123	0.18-0.60%	Concentrations, % % of total	0-0.30 31.1	over 0.30 68.9
Co	5.4	140	0.05-0.10 ppm	Concentrations, ppm % of total	0-0.10 43.1	over 0.10 56.9
Cu	9.0	236	4-10	Concentrations, ppm % of total	0-10 46.6	over 10 53.4
Fe	9.8	256	10-100 ppm	Concentrations, ppm % of total	0-100 24.1	over 100 75.9
Mg	11.1	290	0.04-0.18%	Concentrations, % % of total	0-0.20 35.2	over 0.20 64.8
Mn	11.2	293	20-40 ppm	Concentrations, ppm % of total	0-40 21.0	over 40 79.0
Mo	5.1	133	0.01 ppm or less	Concentrations, ppm % of total	0-3 86.4	over 3 13.6
P	43.2	1 129	0.18-0.43%	Concentrations, % % of total	0-0.30 72.8	over 0.30 27.2
K	7.6	198	0.60-0.80%	Concentrations, % % of total	0-0.80 15.1	over 0.80 84.9
Na	5.6	146	0.06-0.10%	Concentrations, % % of total	0-0.10 59.5	over 0.10 40.5
Zn	6.8	177	10-50 ppm	Concentrations, ppm % of total	0-50 74.6	over 50 22.4

[1] Latin American Tables of Feed Composition (McDowell *et al.*, 1974; McDowell *et al.*, 1977). — [2] Less than 1% of the other minerals were included. — N.R.C., 1971, 1976 and A.R.C., 1965.

(McDowell, 1976; Fick *et al.*, 1976; McDowell *et al.*, 1977). These reports include both confirmed as well as highly suspected geographical areas of mineral deficiencies and toxicities in ruminants.

For grazing livestock the most prevalent mineral deficiency throughout the world is lack of P with reports of deficiencies in at least 38 tropical developing countries (McDowell *et al.*, 1977). Next to P, the minerals most likely to be deficient for grazing livestock are Co and Cu (Table 3).

Cobalt: Young growing sheep are the most sensitive of all animals to cobalt deficiency; next are mature sheep, calves between 6 and 18 months old, and mature cattle in that order (Andrews, 1956). Cobalt deficiency occurs in many regions of Latin America (Table 3) and mostly, but not exclusively, is restricted to grazing ruminants which have little or no access to concentrates. In Brazil Tokarnia and Döbereiner (1973) noted that, except for a lack of P, Co is the most critical mineral (Figure 3 illustrates cobalt-deficient cattle in Brazil).

Prior to the recognition of cobalt deficiency, in many parts of the world cattle could be maintained on pastures deficient in Co only if they were periodically moved to "healthy" ground. Incidence of cobalt deficiency can vary greatly from year to year from an undetectably mild deficiency to an acute stage. In five years at Glenroy, Australia, flocks of sheep were unaffected, whereas in another eight years, clinical signs of variable severity of cobalt deficiency were encountered (Reuter, 1975). Cobalt deficiency signs are non-specific and often difficult to differentiate from energy-protein malnutrition. Cobalt-deficient livestock respond quickly to cobalt treatment, recovering appetite, vigour and weight. Cobalt sub-deficiencies or borderline conditions are extremely common and are characterized by low production rates unaccompanied by clinical signs.

Cattle and sheep grazing *Phalaris tuberosa* in areas of Argentina presented the clinical signs of the disease known as "Phalaris staggers". Cobalt supplementation has been shown to alleviate this condition.

Copper and molybdenum: Throughout extensive regions of the world, lack of Cu is a severe mineral limitation to grazing cattle. Copper deficiencies in ruminants, as with Co, occur mainly under grazing conditions, with clinical signs of the deficiency being rare when concentrates are fed (Ammerman, 1970). Copper deficiency is not usually found in pigs and poultry under practical management conditions.

Ward (1977) categorized copper deficiency into four groups where the feed contained: high levels of Mo (more than 20 ppm); low Cu but significant amounts of Mo (i.e., ratio 2:1); deficient in Cu (less than five ppm); and normal Cu and low Mo, with high levels of soluble protein. It is suggested that the latter situation is the result of high intakes of soluble protein from fresh pasture which increases the amounts of sulphide produced in the rumen, thus resulting in unavailable copper sulphide.

Fick *et al.* (1976) reported low copper tissue (liver or blood) levels for ruminants in Argentina, Brazil, Costa Rica, Cuba, Panama and Peru. Since 1975 researchers at the Instituto Colombiano Agropecuario (ICA) have been analysing liver and forage samples throughout Colombia. Their results indicate that copper deficiencies appear to be borderline-to-deficient over vast areas of Colombia (A. Gil and J. Tritschler, 1977, personal communication). Recently certain areas of El Salvador are reported to be likewise deficient in Cu (F. Perla, 1977, per-

TABLE 3. — **Geographical locations of mineral deficiencies or toxicities of ruminants in Latin America**

Required	
Ca	Argentina, Brazil, Colombia, Costa Rica, Guatemala, Guyana, Mexico, Panama, Peru, Surinam, Venezuela.
Mg	Argentina, Brazil, Chile, Colombia, Costa Rica, Guatemala, Guyana, Haiti, Honduras, Jamaica, Peru, Surinam, Trinidad, Uruguay.
P	Antigua, Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Surinam, Uruguay, Venezuela.
K	Brazil, Haiti, Panama, Venezuela.
Na	Brazil, Colombia, Guatemala, Panama, Surinam, Venezuela.
S	Brazil, Ecuador.
Co	Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, Guyana, Haiti, Mexico, Nicaragua, Peru, Surinam, Uruguay.
Cu (or Mo toxicity)	Argentina, Brazil, Colombia, Costa Rica, Cuba, Guyana, Haiti, Mexico, Panama, Peru, Surinam, Uruguay.
I	Antigua, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Haiti, Nicaragua, Paraguay, Peru, Uruguay.
Fe	Brazil, Costa Rica, Panama.
Mn	Argentina, Brazil, Costa Rica, Panama.
Se	Bahamas, Brazil, Costa Rica, Ecuador, Guyana, Honduras, Mexico, Paraguay, Peru, Uruguay.
Zn	Argentina, Brazil, Costa Rica, Guyana, Panama, Peru, Puerto Rico, Venezuela.
Toxic	
F	Argentina, Guyana, Mexico.
Mn	Brazil, Costa Rica, Peru, Surinam.
Se	Argentina, Brazil, Chile, Colombia, Ecuador, Honduras, Mexico, Peru, Puerto Rico, Venezuela.

Sources: McDowell (1976); Fick *et al.* (1976).

sonal communication). Twenty-three percent of cattle livers from 12 San Carlos ranches (Kiatoko *et al.*, 1976) and 40 percent from 15 Guanacaste ranches (Lang *et al.*, 1976) analysed in Costa Rica were borderline-to-deficient in Cu.

A copper content in feed over 20 ppm can cause chronic poisoning in sheep. Also, it is suggested that normal Cu combined with such low levels of Mo and sulphate (SO_4) may result in copper toxicity of sheep. In reviewing copper toxicity, Todd (1969) concluded that chronic copper toxicity in ruminants is almost entirely confined to sheep.

Clinical signs of molybdenum toxicity are similar to copper deficiency. Both molybdenum toxicity and copper deficiency are generally corrected by providing additional Cu in the animals' diet. In severe molybdenum-toxic areas, injections of copper compounds are often the preferred method of administration since the primary site for Cu × Mo interaction is the gut (Suttle and Field, 1974).

Iodine: Iodine deficiency as manifested by endemic goitre is one of the most prevalent deficiency diseases, having been shown to occur in almost every country of Latin America. Incidence of iodine deficiency has declined in many countries as a result of the widespread use of iodized salt. However, in Latin America endemic goitre remains an exceedingly serious human and livestock problem. Figure 4 shows goitre in a calf in Mato Grosso, Brazil.

Iodine is a constituent of the hormone thyroxine, which regulates metabolic rate in animals; thus iodine, through this mechanism, has a strong influence on livestock growth and reproduction. In iodine-deficient areas, deficiency signs are most frequently observed in young animals in the form of: goitre at birth or soon thereafter; death or weakness at birth; hairlessness at birth (typical in pigs); and infected navels (especially in foals). Iodine deficiency in female breeding animals results in oestrus suppression, and in the male lack of libido.

Although iodine deficiency is caused primarily by low dietary intake of I, its incidence is greatly enhanced by intake of goitrogens that interfere with iodine utilization (Underwood, 1977). The net effect of goitrogens in most instances is to increase the iodine requirement.

The most effective method of goitre prevention is to provide I in the mineral mixture. Unstabilized potassium iodine is less effective under wet tropical conditions since I in this form is readily volatilized or leached. Calcium (Ca) or potassium iodate, stabilized potassium iodine, or pentacalcium orthoperiodate are much more stable forms of I.

Selenium: Consumption of feedstuffs containing both toxic ($>$ five ppm) and deficient ($<$ 0.1 ppm) concentrations of Se presents a worldwide problem to livestock. Table 3 presents Latin American countries where selenosis or selenium deficiency is encountered or suspected, and Figure 5 illustrates selenium toxicity in Colombia. Much of the older literature from Latin America dealt with selenium toxicity; however, with improved techniques of analysis and detection, recent research indicates selenium deficiency to be widespread.

Since 1957 an interrelationship between Se and vitamin E has been established. During the past ten years, death losses due to Se-vitamin E deficiencies have occurred with increasing frequency in pig and poultry operations characterized by complete confinement with little or no use of pastures. As the trend toward confinement and absence of pastures increases in Latin American pig and poultry operations, the incidence of Se-vitamin E deficiency is likely to increase.

In grazing animals three distinct selenium deficiency syndromes have been described: "white muscle disease" (WMD) in newborn or young lambs and calves; unthriftiness, with poor growth rates, which may occur in the absence of any other recognizable disease; and infertility.

Lang *et al.* (1976) reported borderline-to-deficient selenium concentrations in 33 percent of the livers analysed from beef cattle slaughtered in Guanacaste, Costa Rica. Low selenium concentrations have been reported in forages in areas of Chihuahua, Mexico and Guyana (Fick *et al.*, 1976). In Peru a condition in ruminants resembling Se-vitamin E deficiency is reported. When the animals were treated with Se-vitamin E injections, about 70 percent recovered from the condition (Terry, 1964).

Selenium poisoning is often associated with consumption of selenium accumulator plants (for example, *Astragalus* spp.) which may contain up to several thousand ppm Se. At present practical measures for controlling selenium poisoning of grazing livestock rely on pasture rotation and the use of feeds from non-seleniferous areas. Locating seleniferous soils and mapping them in sufficient detail are essential. The selenium content is highest in young plants and declines rapidly at later stages of maturity. Therefore, use of pastures of low selenium content during the growing season and high selenium forages toward the end of the growing season is a very effective control measure.

Fluorine: Although apparently essential for most species, only the toxic effects of F are likely to be of importance to livestock. Fluorine is an accumulative element with fluorosis found in many parts of the world. Chronic fluorosis in livestock is generally observed under three conditions: drinking water high in F; continuous consumption of high F mineral supplements; and grazing fluorine-contaminated forages adjacent to industrial plants which emit fluorine fumes or dust (Underwood, 1977). The fluorine content of common forages seldom reaches more than one to two ppm, since most plants have a limited capacity to absorb this element.

Certain levels of fluorine intake are tolerated by livestock for prolonged periods without any measurable decline in growth, appetite, well-being, fertility, or productivity, despite elevated bone fluoride levels and mild dental and skeletal abnormalities. Toxicity of F is a reflection of amount and duration of ingestion, solubility of fluorides ingested, age of animal, nutrition, stress factors, and individual animal differences.

Cattle are less tolerant to fluorine toxicity than other livestock, those in tropical countries provided with inad-

FIGURE 1. — *Cattle consuming soil at "Hato El Frio" in the Llanos, State of Apure, Venezuela. Note holes in soil from previous consumption. Excessive soil consumption is associated with pronounced mineral deficiencies*

(Photo courtesy of A. Velasco, Hato El Frio, Apure State, Venezuela)

FIGURE 2. — *A cow chewing bone in the "Llanos" region of Santa Maria de Ipire, State of Guarico, Venezuela. Bone chewing is often associated with a phosphorus or other mineral deficiency*

(Photo courtesy of David Morillo, Centro de Investigaciones Agronómicas, Maracay, Venezuela).

FIGURE 3. — *Cobalt-deficient cattle in northern Mato Grosso, Brazil*

(Photo courtesy of [illegible] and Carlos H. Tokarnia, EMBRAPA, [illegible] Brazil)

Some examples of nutritional disorders in livestock caused by trace mineral deficiencies

FIGURE 4. — *Goitre in a calf due to iodine deficiency observed in Rondonapolis, State of Mato Grosso, Brazil*

(Photo by L.R. McDowell, University of Florida, Gainesville, Florida, U.S.A.)

FIGURE 5. — *Selenium toxicity in the selenium toxic region of Puerto Boyacá, Colombia. Misshapen hoof due to selenium injury*

(Photo by L.R. McDowell, University of Florida, Gainesville, Florida, U.S.A.)

FIGURE 6. — *Zinc deficiency lesions in grazing cattle observed in Bethlehem, Orange Free State, South Africa. The major clinical sign is widespread alopecia. The most severe lesions were between the rear and front legs, which cannot be seen. Bleeding of the cracked skin in this area was sometimes observed*

(Courtesy B.D.H. Van Niekerk, Voermol Products Limited, Natal, South Africa).

equate supplies of energy and protein during extended dry seasons being particularly susceptible.

Prevention of fluorosis in Latin America should include analyses of water supplies and phosphates for fluorine content. Lactating cows can tolerate 30 ppm with no apparent difficulty, 40 ppm is a marginal tolerance, and 50 ppm can result in fluorosis within three to five years (NAS, 1974). Only defluorinated phosphates (< 100 ppm) should be given as a supplement to livestock; feeding fertilizer rock phosphate should be avoided.

Iron: Natural feedstuffs usually contain enough Fe to meet the requirements of farm livestock. The notable exception is the baby pig, where iron deficiency is common because placental and mammary transfer are inadequate and milk is very low in this element. In operations where pigs are kept on concrete without access to soil or pasture, iron deficiency anaemia will often result within two or three weeks unless a supplemental source of Fe is available.

Except in animals with severe parasitism or haemorrhaging, iron deficiency is considered rare for grazing livestock owing to generally adequate pasture concentrations together with contamination of plants by soil. Iron supplementation is most warranted for grazing livestock when forages contain less than 100 ppm Fe or insects or parasites are causing substantial blood loss.

Zinc: Since the middle 1950s the importance of Zn in pig and poultry diets has been realized. It was established that a skin disorder in pigs termed parakeratosis could be prevented by supplemented Zn. Excess Ca in the diet hastens the onset of parakeratosis. Since parakeratosis is not entirely absent even in diets containing less than 1.0 percent Ca, Zn should be regularly added to most diets for pigs and poultry in confinement.

Zinc deficiency in cattle was once thought unlikely under practical conditions. Zinc deficiencies, evidenced largely by skin disorders and reduced performance, have been reported under natural conditions in Guyana, Finland, Norway, United States, Republic of South Africa (Figure 6) and Venezuela (McDowell *et al.*, 1977). Legg and Sears (1960) demonstrated a parakeratosis skin disorder in cattle of Guyana which were consuming forage containing 18 to 42 ppm Zn.

Manganese: Manganese deficiency is seldom encountered in ruminants and pigs fed diets composed of natural ingredients. A deficiency in poultry is more common due to the higher requirement for this element. Manganese deficiency in beef cattle results in delayed oestrus and conception, and calves born with neonatal skeletal abnormalities (Rojas *et al.*, 1965). Low manganese forages have been reported in the following Latin American countries: Argentina, Brazil, Costa Rica and Panama. Low liver manganese levels suggestive of a manganese deficiency were noted in 63 percent of the cattle examined in western Costa Rica (Lang *et al.*, 1976). Clinical signs suggestive of a manganese deficiency have also been reported from this region (Lang, C.E., 1977, personal communication). In a different region of Costa Rica, characterized by volcanic soils, manganese toxicity was observed which resulted in low reproductive rates of cattle (Fonseca and Davis, 1968; Lang, 1971).

TABLE 4. — **Detection of specific mineral deficiencies or toxicities in cattle**[1]

Element	Dietary level	Tissue	Critical level indicating deficiency
Ca	0.18-0.60%	Plasma	8 mg/100 ml
Mg		Serum	1-2 mg/100 ml
		Urine	2-10 mg/100 ml
P	0.18-0.43%	Plasma	4.5 mg/100 ml
K	0.60-0.80%		
Na	0.10%	Saliva	100-200 mg/100 ml
S	0.10%		
Co	0.05-0.1 mg/kg	Liver	0.05 mg/kg
Cu		Liver	25 mg/kg
I		Milk	300 µg/day
Fe		Haemoglobin	10 g/100 ml
		Transferrin	13-15% saturation
Mn	20-40 mg/kg	Liver	6-10 mg/kg
Se	0.05-0.10 mg/kg	Liver	0.25-0.5 mg/kg
Zn	10-50 mg/kg	Plasma	0.04 mg/100 ml
			Critical level indicating toxicity
Cu		Liver	700 mg/kg
F		Bone	4 500-5 000 mg/kg
Mn	1 000-2 000 mg/kg	Hair	70 mg/kg
Mo	6-20 mg/kg		
Se	5 mg/kg	Liver	5-15 mg/kg

[1] References for critical levels: McDowell (1976).

Detection of mineral deficiencies or toxicities. The most reliable method of confirming mineral deficiencies is response derived from specific mineral supplementation. The majority of mineral imbalances, particularly borderline conditions, do not result in clinical signs specific to a single mineral. Soil mineral analyses can sometimes provide clues to livestock mineral deficiencies, but more often they are unreliable and difficult to interpret. A major disadvantage of forage element analyses to assess mineral adequacy for grazing livestock is the uncertainty of samples representing what livestock consume. Nevertheless, forage mineral analyses are preferable to soil analyses, while animal tissue analyses most accurately portray the contribution of the total environment (forage, soil, and water) to meeting livestock mineral requirements. Recently excellent reviews have discussed methods of chemically diagnosing mineral deficiencies. Since mineral analyses are complicated and expensive, it is important to select and analyse the minimum number of plant and animal tissues which are most indicative of the mineral status. Table 4 illustrates analyses of consider-

able value in assessing specific mineral deficiencies and toxicities in cattle.

Present knowledge of trace element imbalances in livestock is derived from the study of a few geographical areas, and there is no way to predict which trace element problems may exist in the remaining vast territories not yet investigated (Mertz, 1976). It is therefore important to implement a systematic method to locate mineral imbalances in Latin America and other developing regions.

A technique for mapping potential areas of mineral deficiencies and toxicities. Mineral deficiencies or toxicities in grazing livestock can be predicted by use of a systematic mapping survey technique or regional reconnaissance. Egan (1975) reports that the sampling and analysis of stream bed sediments have revealed areas of hitherto unsuspected molybdenum-induced copper deficiency in sheep and cattle, manganese deficiency in cattle and cobalt deficiency in sheep. Kubota (*et al.*, 1967, and 1968) analysed selenium and cobalt levels of U.S. forages for the purpose of relating concentrations of these to selenium- and cobalt-responsive diseases of livestock. Similar mapping techniques based on mineral forage analyses have been completed in Brazil and Venezuela. Likewise, a mapping technique based on specific mineral concentrations in animal tissue has also been undertaken in Brazil, Venezuela and Panama (McDowell, 1976).

Since 1974 the University of Florida, with financial support from the U.S. Agency for International Development, has been engaged in cooperative mineral research with institutions in ten Latin American countries (Fick *et al.*, 1976). The purpose of this research is also to locate mineral deficiencies or excesses in ruminants by use of a systematic mapping technique which analyses plant and animal tissues and by observing the biological response from mineral supplementation trials.

Mineral supplementation for livestock. The most devastating economic result of mineral deficiencies is reproductive failure, with mineral supplementation dramatically increasing fertility levels in grazing cattle from many parts of the world (McDowell, 1976). Table 5 illustrates reports from Latin American countries where the calving percentage was increased by mineral supplementation. The specific mineral or minerals responsible for increasing reproductive performance in the above experiments is unclear. Phosphorus probably contributed most to this improvement. Nevertheless, bone meal as a source of P is likewise often a good source of essential trace elements.

For monogastric animals, minerals can best be provided by inclusion of the required elements in the concentrate mixture. This is most critical if monogastrics are housed in complete confinement without access to pasture.

Provision of mineral supplements is more complicated for grazing ruminants. Problems concerned with mineral supplementation programmes in Latin America include:

- insufficient chemical analysis and biological data to determine which minerals are required and in what quantities;
- lack of mineral consumption data needed for formulating supplements;
- inaccurate and/or unreliable information on mineral ingredient labels;
- supplements that contain inadequate amounts or imbalances;
- standardized mineral mixtures that are inflexible for diverse ecological regions (i.e., supplements containing Se distributed in a selenium-toxic region);
- farmers not supplying mixtures as recommended by the manufacturer (i.e., mineral mixtures diluted 10:1 to 100:1 with additional salt);
- difficulties involved with transportation, storage and cost of mineral supplements.

Despite the dramatic effects of bone meal on weight gains and pregnancy rates, Bauer (1968) suggested that the high cost of transportation eliminated the profitability of bone meal supplementation in the Llanos of Bolivia. Additional observations, however, have indicated that supplemental bone meal increased the calving percentage and weight gains substantially, thereby making supplemental bone meal economically profitable in the Beni State of Bolivia (Bauer, B., 1976, personal communication).

In order to evaluate a mineral sup-

TABLE 5. — **Latin American studies on effects of mineral supplementation on increased calving percentages**

Country	Control [1]	Control + mineral supplement	Reference
Bolivia	67.5	[2] 80.8	Bauer (1976, unpublished data).
Brazil	55.0	[2] 77.0	Conrad and Mendes (1965).
Brazil	49.0	[2] 72.0	Guimarães and Nascimento (1971).
Brazil	25.6	[2] 47.3	Grunert and Santiago (1969).
Colombia	50.0	[3] 84.0	Stonaker (1975).
Panama	62.2	[4] 68.8	Ríos Araúz (1972).
Panama	42.0	[2] 80.0	Poultney (1972, personal communication).
Peru	25.0	[5] 75.0	Echevarría *et al.* (1974).
Uruguay	48.0	[2] 64.0	De León Lora (1963).
Uruguay	86.9	[2] 96.4	Schiersmann (1965).

[1] Control animals received only common salt (NaCl). — [2] Bone meal. — [3] Complete mineral mixture. — [4] Dicalcium phosphate + triple superphosphate. — [5] Dicalcium phosphate + copper sulphate.

plement for ruminants, it is necessary to have an approximation of: the requirement for each element; the biological availability of the element in the compounds supplied; the daily intake per head of both mineral mixture and total dry matter; and the concentration of elements in the mineral mixture (Houser *et al.*, 1977). Table 6 presents an example of mineral allowances and proportions supplied by a mineral mixture (typical in Latin America) offered "free choice" on range or pasture. This particular mixture supplied only 5 percent of the zinc requirement and relatively low quantities of Cu, Fe and Mn.

An acceptable mineral supplement should provide a "significant portion" of the requirement for each mineral, it being generally believed that this figure should be at least 25 to 50 percent. In known trace mineral deficient regions it may be desirable to provide 100 percent of specific elements required, especially in areas where they are known to be low in forages (Ammerman, 1977).

As a low-cost insurance to provide adequate mineral nutrition, "complete" mineral supplements should be available "free choice" to ruminants (Cunha *et al.*, 1964). A "complete" mineral mixture should include salt, a low fluoride phosphorus source, Ca, Co, Cu, I, Mn and Zn. Selenium, Mg, K, S, Fe or additional elements can be incorporated into a mineral supplement as new information suggests a need. Calcium, Cu or Se when in excess can be more detrimental to ruminant production than any benefit derived by providing a mineral supplement.

In regions where high forage Mo predominantes, three to five times the copper content in mineral mixtures is needed to counteract molybdenum toxicity (Cunha *et al.*, 1964). Data from Florida (Becker *et al.*, 1965) and Montelonia, Colombia (Gil, A., 1975, personal communication), show that salt content of water supplies is important in formulating mineral supplements since cattle consume less minerals when water is high in salt. The economic return on mineral investment has been at least two to one in some studies (Conrad, 1976).

TABLE 6. — **Mineral allowances and proportions supplied by a mineral mixture offered "free choice" on range or pasture**

Element	Dietary allowance [1]	Mineral mixture (%) [2, 3]	Amount from mineral mix	% of allowance from mineral mix
NaCl	0.50%	50.0	0.25%	50.0
Ca	0.30%	12.0	0.06%	20.0
P	0.25%	12.0	0.06%	24.0
Mg [4]	2 000 ppm	—	—	—
Co	0.1 ppm	.005	0.25 ppm	250.0
Cu	10 ppm	.025	1.25 ppm	12.5
I	0.80 ppm	.010	0.50 ppm	62.5
Fe	100 ppm	.250	12.5 ppm	12.5
Mn	25 ppm	.050	2.5 ppm	10.0
Se	0.1 ppm	.0005	0.03 ppm	30.0
Zn	50 ppm	.050	2.5 ppm	5.0

[1] N.R.C., 1971, 1976 and A.R.C., 1965 recommendations. — [2] Composition similar to certain mineral mixtures available in tropical countries. — [3] It is assumed that mineral consumption will average approximately 0.5% of the total dietary intake. This is based on an estimated intake of 50 g of mineral mixture for cattle and 10 kg of total dry feed per head daily. The calculation is made as follows:

$$\frac{\text{\% element in mineral mixture} \times \text{daily intake of mineral mix (g)}}{\text{Total daily dry matter intake (g)}} = \text{\% element in total diet}$$

If, for example:
Copper in mineral mixture (%) = .025
Daily intake of mineral mixture (g) = 50
Total daily intake of dry matter (g) = 10 000

Then: $\frac{.025 \times 50}{10\ 000} = .000125\%$ or 1.25 ppm

[4] Magnesium is generally not added except for special mixtures for lush winter or spring grazing of tetany-prone pasture.

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Early weaning of pigs: a major advance in pig production?

M.J. Newport

Sow productivity can be assessed by the number of pigs weaned per sow per year and has a major effect on the efficiency of meat production from pigs. The age of weaning can greatly influence sow productivity by its effect on the farrowing interval. The mortality rate of suckled pigs between birth and 56 days of age, which is usually 20 to 25 percent of all live births and is a source of serious economic loss under practical conditions, could be drastically reduced by artificial rearing, that is, by weaning at or soon after birth. The latter also offers the possibility of greatly increasing the growth rate of the baby pig, because growth in sucking pigs is limited by the supply of milk from the sow. Clearly, weaning at or soon after birth has a great potential for increasing the efficiency of pig production. Unfortunately, at the present time all attempts at artificial rearing under practical conditions have failed for various reasons: difficulties in reproduction in sows whose pigs have been early-weaned; gastroenteritis (scouring) in the weaned pigs; and, to a lesser extent, inadequate knowledge of the nutritional requirements of the baby pig. However, weaning between 21 and 35 days of age can be successfully applied under practical conditions.

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Artificial rearing has also been used as a technique for disease control in the establishment of a minimal-disease herd by rearing pigs derived by hysterectomy (Robertson *et al.*, 1971). A system has also been described for rearing orphan pigs and those in excess of a sow's rearing capacity which might be used when fostering is not available (English and Smith, 1976).

Sow productivity

Sow productivity is dependent on the farrowing interval, the number of live pigs born in a litter, and pre-weaning mortality. Decreasing the length of the lactation period by early weaning could increase the number of litters per sow per year from 2.05, when the pigs are weaned at 56 days of age, to 3.0 if pigs were weaned at birth, assuming an interval of 7 days between weaning and conception (Figure 1).

English and Smith (1975) showed that neonatal mortality occurs mainly in the first two days of life: of all pigs born alive 19.6 percent died by 2 days of age, compared with an overall mortality rate of 24.4 percent up to 56 days of age. Therefore a significant reduction in mortality could only be achieved by weaning before 2 days of age; if weaning is delayed until 7 days of age, mortality could not be reduced by more than approximately 3 percent. Artificial rearing from birth cannot eliminate mortality due to congenital or genetic abnormalities, or extreme weakness at birth; however, in their survey, English and Smith (1975) found that these factors accounted for only 5 percent of all live births. Allowing for a further 5 percent mortality during the rearing period, it is unlikely that artificial rearing could reduce mortality to below 10 percent of all pigs born alive.

The effect of age of weaning on the theoretical number of pigs reared to 56 days of age per sow per year is shown in Table 1. The calculations are based on litter sizes of 10.5 or 12, the former figure being close to the present average found on a number of farms in the United Kingdom (Meat

TABLE 1. — **Annual sow productivity as affected by age of weaning**

Weaning age (days)	Litters per year	Pigs weaned [1]		Pigs reared to 56 days age [2]	
		[3] 10.5	[3] 12	[3] 10.5	[3] 12
0	3.0	10.5	12.0	28.3	32.4
2	2.95	9.2	10.5	25.7	29.5
7	2.85	8.6	9.9	24.0	27.6
21	2.5	8.1	9.3	19.9	22.1
35	2.3	8.0	9.2	18.0	20.8
56	2.05	7.9	9.1	16.2	18.7

[1] Number of pigs weaned at each age calculated by using mortality data of English and Smith (1975). — [2] Mortality after weaning assumed to be 10 percent (0-2 d weaning) and 2 percent (7-56 d weaning). — [3] Number of pigs born alive/litter.

and Livestock Commission, 1975; Ridgeon, 1976), and the latter a reasonable target for the future, especially as early weaning might shift the emphasis in genetic selection more toward prolificacy, with less importance attached to milk production. Thus, compared with weaning at 21 or 56 days of age, weaning at birth could increase sow productivity by approximately 40 or 70 percent respectively.

However, both experimentally and under commercial conditions, early weaning, particularly below 21 days of age, has been accompanied by a decline in the size of the subsequent litter. Cole, Varley and Hughes (1975) investigated the effect of lactation lengths varying from 4 to 42 days of age on subsequent litter size, and found a reduction from 12.7 pigs per litter when weaning after 21 days of age to 9.6 when weaning was carried out below 21 days of age (Figure 2). The reduced litter size after very early weaning seems to be due to embryonic mortality in early pregnancy which may be associated with a decreased uterine length (Varley and Cole, 1976). The effects of early weaning on the physiology and endocrinology of the sow are well documented (Polge, 1972), but little attempt has yet been made toward solving the problem of reduced litter size following early weaning.

Aumaitre (1972) reported a reduction of one pig per litter in the subsequent litter following weaning at 10 compared with 21 days of age, but after the next parity litter size was comparable at both ages of weaning. Some support for these results is given by surveys of commercial production in France (Aumaitre, Perez and Chauvel, 1975; Legault *et al.*, 1975) in which litter size was reduced only by weaning below 10 days of age. However, data from four Belgian farms (Van der Heyde, 1972) indicated a small but regular reduction in litter size (approximately 0.5 pig per litter) when weaning age was reduced from 56 to 21-28 days of age, and again when age of weaning was further reduced to 16-20 days of age. Weaning below 15 days of age resulted in 1.6 pigs per litter fewer than at 21 days.

The results of Van der Heyde and Cole *et al.*, (1975) indicate that weaning at 7 days of age or earlier is likely to reduce the subsequent litter size by at least two pigs. The effect of this on the potential number of pigs weaned

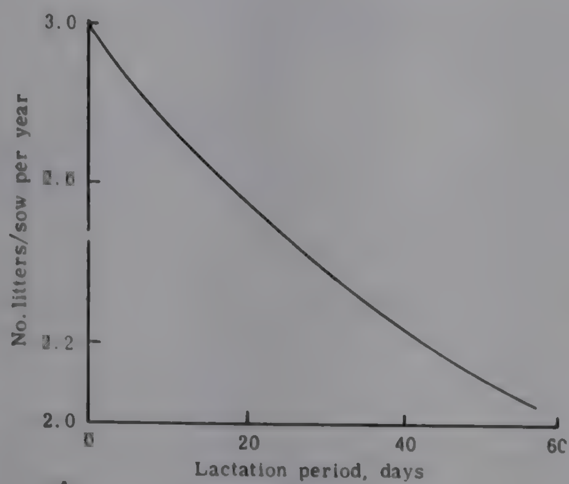


FIGURE 1. — *Effect of lactation period on number of litters/sow/year.*

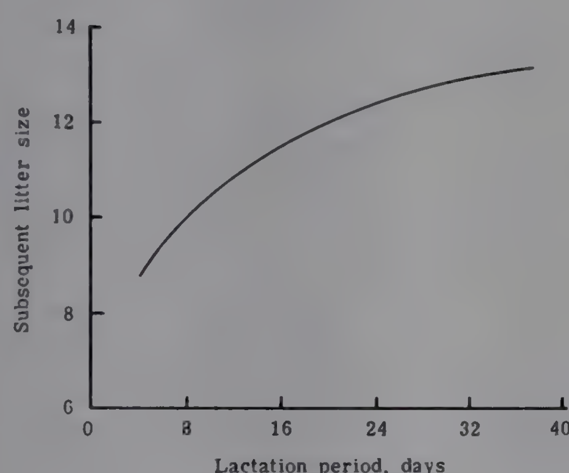


FIGURE 2. — *Reduction in subsequent litter size after early weaning* (after Cole, Varley & Hughes, 1975).

per sow per year, as shown in Table 1, is to reduce the potential for 0-2 day weaning to near that obtained from weaning at 21 days of age. Thus subsequent litter size is an important factor in determining the feasibility of weaning at or soon after birth.

A possible method for overcoming the problem of reduced litter size, following artificial rearing, could be the use of a single litter system (Jones, 1972). Gilts mated at 88 kg live weight can produce satisfactory litters and be available for slaughter at 130 kg. The adoption of this system would require a suitable market for pigs slaughtered at this weight and the ability to rear pigs from birth under practical conditions. The normal increase in litter size which occurs through successive parities would also be lost.

A small increase in the interval between weaning and oestrus has been noted in sows whose pigs were weaned below 21 days of age (Cole *et al.*, 1975; Varley and Cole, 1976). This increase is not likely to be a problem under practical conditions; for example Van der Heyde reported an increase of 4.5 days, but this was only when weaning occurred at 5 days of age or earlier.

Under commercial conditions sow productivity has been shown to increase when pigs are weaned at 21 to 28 compared with 35 to 56 days of age. A survey of 2 510 French farms (Ferradini, 1976) showed that sow productivity was highest when weaning was at 21 days of age (Table 2), with the best 20 percent of all farms achieving 22 to 24 pigs per sow per year. When pigs were weaned at 35 days of age, only 5 percent of the farms could achieve this level of productivity. Ridgeon (1976) showed that in the United Kingdom sow productivity and the financial return per sow favoured weaning at three or four weeks of age compared with later ages (Table 3).

Nutrition of the weaned pig

Although the requirements of the baby pig for many nutrients cannot be defined with any precision, sufficient knowledge is available to formulate diets which will promote satisfactory performance in pigs weaned at any age from birth onward. The digestive enzyme system is immature in the newborn pig and limits the choice of dietary ingredients; for example, only small amounts of starch can be tolerated in the diet due to an insufficiency of pancreatic amylase. Activities of pepsin in the stomach, and pancreatic trypsin and chymotrypsin are also low at birth and do not increase appreciably for several weeks (Aumaitre, 1972a). The low levels of proteolytic enzymes may hinder the digestion of non-milk protein in the baby pig.

Where pigs are weaned at 14 to 21

TABLE 2. — **Sow productivity at different ages of weaning in France**

Age at weaning (days)	21	28	35	42	49
Number of farms	202	508	763	685	281
Number weaned per sow per year	20.05	19.06	18.26	17.93	17.32

Source: Ferradini (1976).

TABLE 3. — **Sow productivity at different ages of weaning in the United Kingdom**

Age at weaning (weeks)	3 and 4	5 and 6	7 and 8
Number of farms	25	84	15
Litters per sow per year	2.24	1.98	1.78
Number weaned per sow per year	19.7	17.4	15.5
Weaner live weight at 56 days of age, kg	17.9	17.9	17.7
Margin per sow, £	72.55	58.50	34.03

Source: Ridgeon (1976).

TABLE 4. — **Performance of artificially reared and suckled pigs from 2 to 28 days of age**

Scale of feeding	Intake relative to scale A	Weight gain (g/day)	Dry matter consumed (g) per g weight gain
A	1.0	201	0.81
B	1.25	276	0.82
C	1.5	297	0.89
D	2.25	326	0.96
Suckled pigs		[1] 210-220	

Source: Braude *et al.* (1970).
[1] Barber, Braude and Mitchell (1955).

days of age, diets based on cereal products and good-quality protein, usually mainly of vegetable origin, are satisfactory. Inclusion of small quantities of dried skim milk to assist palatability and ensure an adequate feed intake is desirable, but not essential. However, artificially reared pigs may require a large proportion of dried skim milk or other milk products in the diet. It is essential that a milk replacer be used in any practical system of artificial rearing to replace all or most of these milk products at the earliest age and to the maximum extent possible. Feeding at frequent intervals may assist the digestion of the diet, as it has been found that hourly feeding improved performance with diets containing cow's milk (Braude *et al.*, 1970). Performance of pigs weaned at 2 days of age was satisfactory when the diet contained equal amounts of protein from dried skim milk and fish protein concentrate (Newport, 1976). Complete replacement of dried skim milk by fish protein had an adverse effect on performance and nitrogen retention, which may be due to a deficiency of proteolytic enzymes or less efficient absorption of fish protein (which, unlike milk protein, does not coagulate in the stomach and may flow through the intestine at an increased rate).

Growth potential of artificially reared pigs

A growth rate which greatly exceeds that for sucking pigs can be attained by artificial rearing (Table 4). Maximum growth is only possible if liquid diets, containing 15 to 20 percent dry matter, are given, as dry matter intake will be much greater than from the same diet fed as dry pellets (Table 5). Increasing the growth rate did increase the relative amount of lipid in the carcass of the 28-day-old pig (Table 6), but the significance, if any, of this on the performance of the pig during the fattening period and on carcass quality has not been studied. Restriction of feed intake in the artificially reared pig is essential, or susceptibility to gastroenteritis will be increased, particularly if feed intake approaches *ad libitum* (Braude *et al.*, 1970).

Gastroenteritis (scouring) in artificially reared pigs

Scouring is a serious problem in artificial rearing particularly when a high growth rate is desired. At Shinfield the incidence of scouring is very variable but in some experiments so severe as to result in up to 20 percent mortality. The cause (or causes) of scouring in artificially reared pigs is uncertain, but microbial or nutritional factors must be involved.

Nutritional effects, other than excessive feed intake, are unlikely to be involved provided that diets are compatible with the stage of development of the digestive enzyme system; for example, starch, sucrose and maltose should be avoided as the amounts of amylase, sucrase and maltase in the

TABLE 5. — **Performance of artificially reared pigs up to 28 days of age fed either a liquid or dry pelleted diet from 7 days of age**

	Liquid diet	Dry diet
Live weight at 28 days of age, kg	8.0	5.4
Feed consumed, kg dry matter	6.32	3.59

Source: Braude and Newport (1977).

TABLE 6. — **Effect of level of feeding on carcass composition of artificially reared pigs at 28 days of age**

Level of feeding	Carcass weight (kg)	Total (g) in carcass		
		Dry matter	Fat	Nitrogen
Low	7.2	2 200	766	170
Medium	8.0	2 814	1 214	195
High	8.5	3 130	1 430	196

Source: Braude *et al.* (1971).

Rearing in cages from 21 days of age

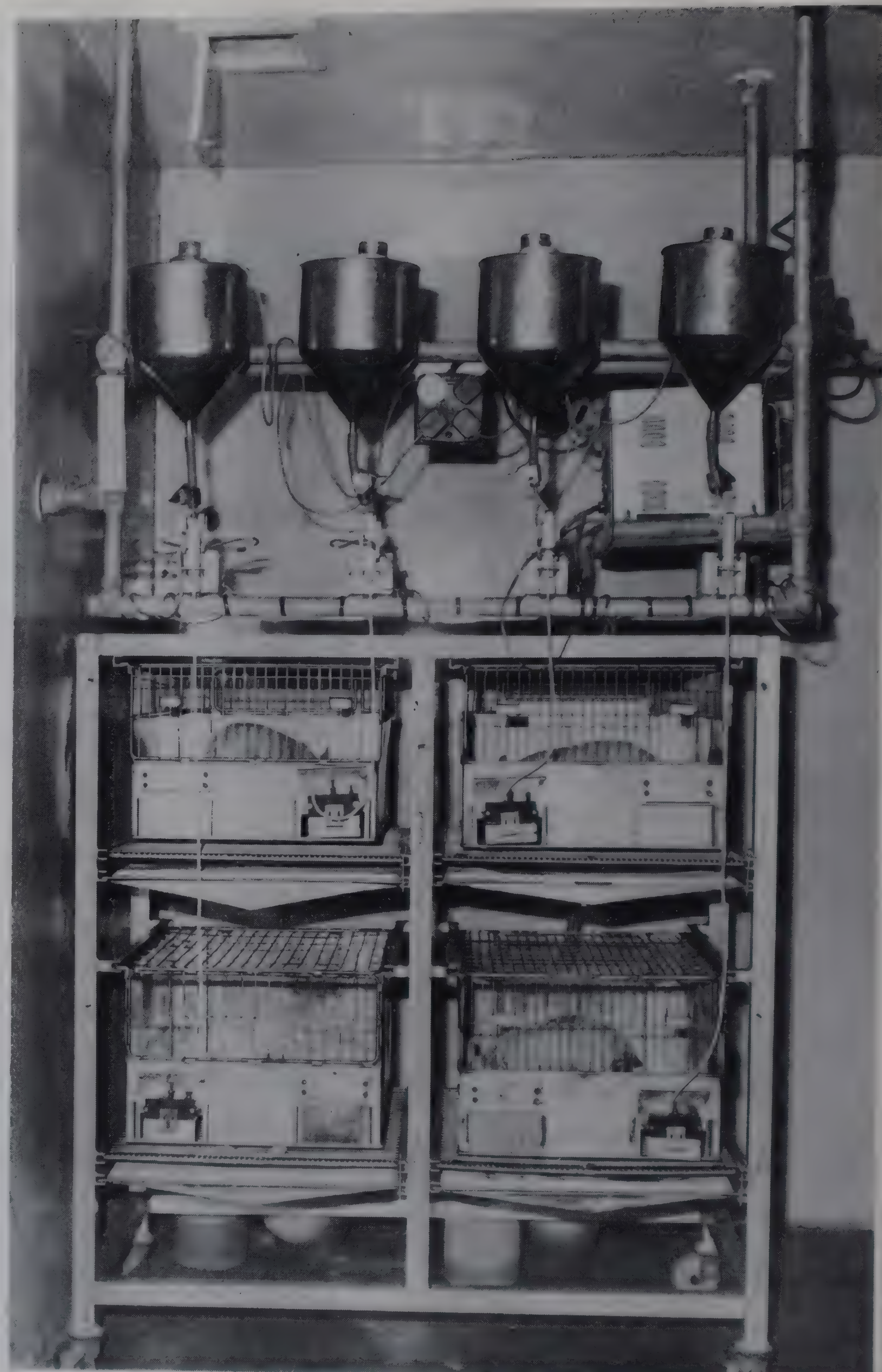
digestive tract of the newborn pig are very limited (Aumaitre, 1972a).

The pig is born without any immunity to infection as no placental transfer of antibodies occurs, and all antibodies are obtained from the sow's colostrum and milk. The antibody activity of the colostrum is much greater than that in milk, and absorption of some of the intact immunoglobulins into the circulatory system will occur during the first 48 hours of life (Jones, 1972a). The continual bathing of the intestine by these low concentrations of antibody in milk after ingestion of colostrum has ceased may also be important in combating infection (Porter, Noakes and Allen, 1970). Therefore, artificial rearing does increase the susceptibility of the pig to bacterial or viral infection as it is deprived of maternal antibodies when weaned on to a milk replacer. Artificial rearing from birth has been successful under experimental conditions either by rearing in strict isolation (Robertson *et al.*, 1971) or by using cow's colostrum as a substitute for sow's colostrum (Senft and Klobosa, 1971). From many experiments

conducted at Shinfield, rearing from 2 days of age does not require either of these precautions, at least under experimental conditions.

In artificially reared pigs, scouring is nearly always accompanied by gastric stasis (White *et al.*, 1969), which may create a more favourable environment for proliferation of bacteria. However, recent work at Shinfield (Barrow, Fuller and Newport, unpublished) suggests that *E. coli* are not a primary cause of scours in artificially reared pigs. Although the numbers of *E. coli* in the stomach and small intestine increase rapidly after weaning at 2 days of age, a similar increase occurs in both healthy and scouring pigs, and pathogenic serotypes of *E. coli* are only rarely isolated. In addition, scouring is still observed in some pigs even when *E. coli* have been eliminated from the alimentary tract after feeding antibiotics.

The involvement of viruses in scouring in 28-day-old weaned pigs has been demonstrated by Woode *et al.* (1976) who isolated rotaviruses from 9 out of 23 outbreaks of scouring and showed that the isolates would infect gnotobiotic pigs. In the pigs reared artificially at Shinfield rotaviruses have been found in the small intestine of all pigs which were scouring, but only in a few of the healthy pigs (Barrow, Brooker, Fuller and Newport, unpublished).



Experimental equipment for artificial rearing developed at National Institute for Research in Dairying, U.K.

Environmental requirements

A high standard of hygiene is required in any system for artificial rearing or early weaning, particularly for weaning at birth, which may require the isolation of the pigs from the external environment. Any production system should permit a thorough cleansing of the rearing accommodation between successive batches of pigs. Schneider and Bronsch (1973) reported that adopting this procedure considerably improved the performance of pigs weaned at 21 days of age.

The maintenance of a suitable environmental temperature is very important. The critical temperature (i.e., the minimum environmental temperature at which normal body temperature is maintained without resort to catabolism of energy reserves in the body) of the newborn pig is about 34°C (Mount, 1968). Under experimental conditions the provision of an environment maintained at 30°C for 2-day-old pigs, reducing to 20°C by 14 days of age, has given good results (Braude *et al.*, 1970).

Environmental requirements have been proposed for pigs weaned at 10 days of age and are described in a review by Baxter (1972):

Temperature:	27-29°C
Relative humidity:	60 percent
Air movement:	0-15 m/sec

Keeping the environment constant and maintaining a low level of lighting is

considered important; sudden fluctuations in temperature and draughts should be avoided.

It should be emphasized that the proposed standards for environmental requirements are largely empirical and have not been subjected to detailed scientific investigations.

- Control of the environment to the standards indicated requires sophisticated equipment, particularly if pigs are weaned at or below 10 days of age. Artificial rearing might also require the use of automated feeding equipment, as it has been shown that performance is improved when pigs are fed at hourly intervals (Braude *et al.*, 1970).

A greater capital investment will be required for an early-weaning system compared with weaning at 49 to 56 days of age. In situations applicable to the United Kingdom, requirements for housing and their effect on capital investment needs have been discussed by Baxter (1972) and Brent (1975). Most efficient use of buildings is obtained by rearing in cages (perhaps tiered) with raised wire mesh floors.

- In conclusion, weaning below 21 days of age cannot be recommended. The optimum weaning age will vary, depending on the availability of suitable ingredients for the diet, the technological ability to meet the environmental requirements, the availability of capital investment, and the standard of stockmanship. Under suitable conditions, improvements in sow productivity, and financial profitability can be made by weaning at 21 compared with 28 to 56 days of age.

The maximum increase in the efficiency of pig production can only be obtained by weaning within the first two days of life (artificial rearing), but before this can be applied in practice two major problems need to be solved:

- the reduction in subsequent litter size;
- gastroenteritis in the artificially reared pig.

If solutions to these two problems can be found, then the scene will be set for a major advance in pig production.

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The growth of Bolivia's dairy industry

L. Barrón

The agricultural sector accounts for about 15 percent of Bolivia's gross national product and milk products comprise 8.5 percent of agricultural imports. Mining is the mainstay of the country's economy, producing 61 percent of export earnings. In this traditionally mining country the dairy industry is only just emerging.

Of the nine departments into which Bolivia is divided, the only one with any tradition of dairying is Cochabamba, a temperate valley suitable for raising dairy cattle, lying at an altitude of 2 600 m in the centre of the country, having an average temperature of 18°C. At present about 10 000 head of cattle of pure and mixed strains of the Holstein-Friesian breed are raised, producing an average annual yield of 3 000 kg of milk, with a fat content of 3.4 percent. In 1960 the Bolivian Development Corporation, in cooperation with UNICEF, installed the first milk-processing plant in Cochabamba; this constituted the cornerstone for the development of the dairy industry in Bolivia.

The country's three ecological zones — high plateau, valleys and plains — have marked differences in altitude — 4 000, 2 600 and 400 m respectively — with mean temperatures of 12°C, 19°C and 25°C and rainfall varying between 500 and 1 200 mm/year. Two of these zones possess conditions favourable for dairy farming, but the high plateau, because of its climate and altitude, is a more difficult area for this activity.

Milk is still in short supply in Bolivia. Skimmed milk powder, condensed milk and evaporated milk valued at approximately US$ 3.5 million are imported into the country every year; if milk products smuggled into the country (mainly from Argentina) are added, import figures reach US$ 4 million. The annual per caput consumption of milk products for a population of 4.7 million is about 12 kg.

Among the factors limiting dairy development are: traditionally low consumption of milk products, particularly in rural areas; traditional farming activities that make it difficult for the peasant farmer to change rapidly to dairying; financial limitations, the type of credit offered by banks being unsuitable for the requirements and procedures of the dairy industry; and lack of adequate technical assistance at the producer level.

The National Dairy Development Plan

Government objectives. It was recognized that the problems of public health, malnutrition, child morbidity and mortality caused by insufficient availabilities of food with a high protein/calorie value were reaching alarming proportions. It was therefore considered essential to introduce a sound policy for the staple food industries.

Almost half the children in Bolivia under two years of age show symptoms of nutritional deficiency, and the situation is tending to worsen; in some mining sectors infant mortality reaches 25 percent. These figures are particularly significant because they refer to a population that is predominantly young (50 percent being under twenty); as a result the life expectancy of a Bolivian is about 47 years.

The Bolivian Government, realizing the implications of malnutrition that affect the majority of the population, drew up a National Dairy Development Plan (NDDP) in conjunction with FAO's International Scheme for the Coordination of Dairy Development (ISCDD). This was approved by the Ministry of Planning and Coordination in 1971, and its basic objectives are:

- to replace imported milk products now costing approximately US$ 4 million per year;
- to increase the per caput consumption of milk products in Bolivia from the present annual level of approximately 12 kg;
- to supply milk products to the vulnerable low-income sectors of the population through programmes for school meals, milk distribution points and so on. At present, owing to the lack of domestic raw material, these programmes are being operated with donations from abroad;
- to continue and to increase the infant feeding subsidy, by which children of insured workers have the right to receive, in their first year of life, 3 700 g of whole milk powder per month, and the mothers 1 300 g of skim milk powder per month;
- to educate consumers, since Bolivians consume few milk products (in rural areas almost no milk at all is consumed);
- to train personnel to carry out the NDDP.

The NDDP thus forms an integral

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part of Bolivia's Economic and Social Development Plan for the five-year period 1976 to 1980, the objectives set in the context of food and nutrition being to satisfy the demand for staple foods so that recommended calorie and protein requirements can be met, and to increase progressively national food production to meet these requirements.

Formulation. Of the countries expressing interest in participating in the ISCDD, Bolivia was the second country, after Sri Lanka, to complete its studies and formulate a national plan.

An FAO mission consisting of an animal production specialist, a milk processing specialist and an economist visited Bolivia in March 1971 with the following terms of reference:

- to analyse the Bolivian situation with regard to dairy production, processing, marketing and trade, as well as the consumption of dairy products and their importance as a source of animal protein;
- to assess the importance of dairying and dairy development in the overall economy and development plans of the country;
- to assess the existing governmental plan for dairy production, consumption and trade, including welfare milk distribution schemes and related legislature and price policy measures, and to assist in making any necessary amendments to the plan;
- to identify bottlenecks in the plan, including in particular needs for capital, commodity aid, technical assistance and equipment, and to work out detailed project proposals for national, international and bilateral financing to overcome these bottlenecks;
- to work out a detailed report on the above to serve as a basis for a plan to be circulated to potential donor governments and organizations cooperating in the ISCDD.

The World Food Programme (WFP) also requested the mission to evaluate a request submitted for a milk reconstitution plant for La Paz.

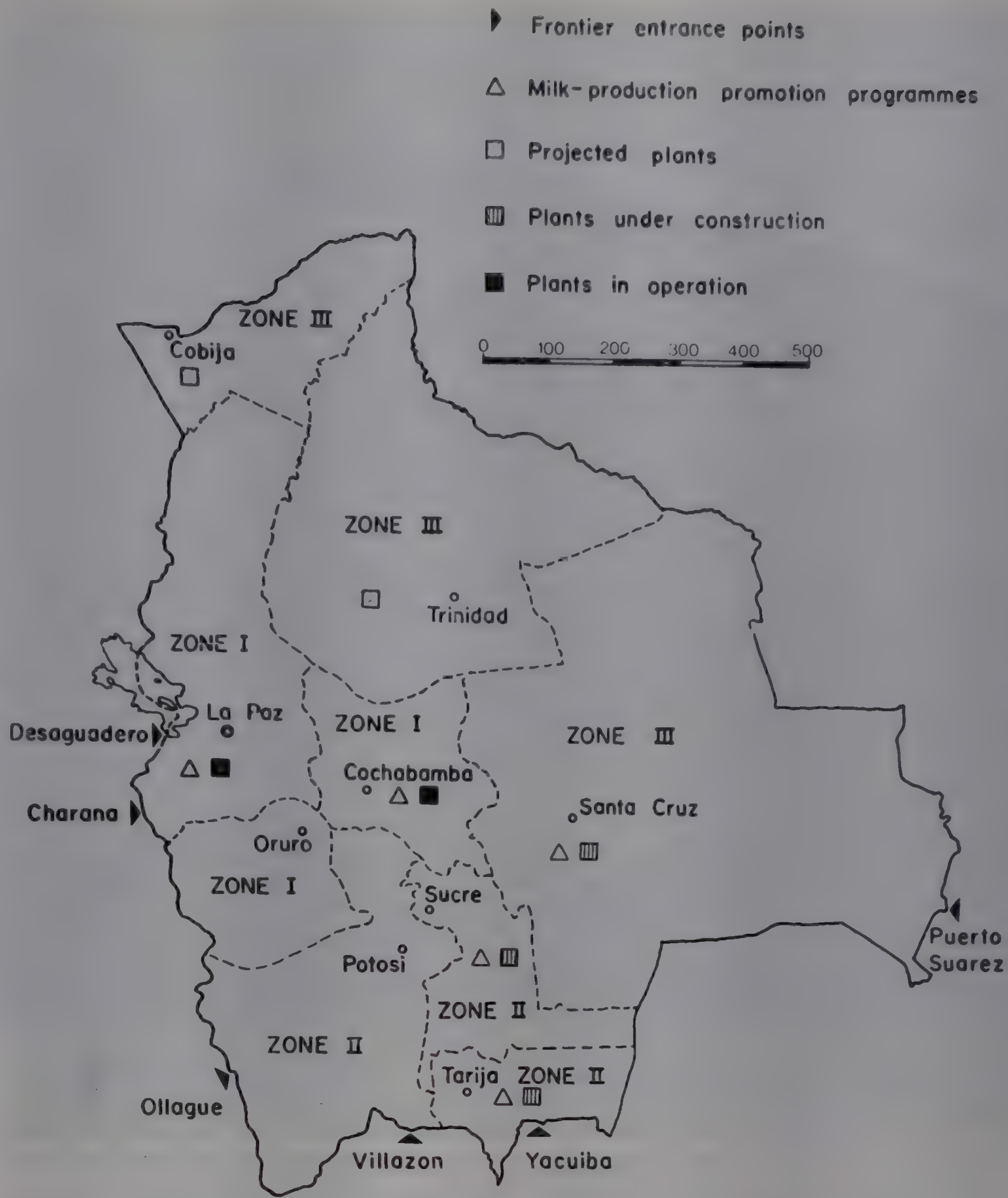


FIGURE 1. — *Bolivia; map showing dairy development zones*

The mission found proof of effective action in dairy development and identified the limiting factors. The Government planned to expand milk production in a number of zones, combining this expansion with the installation of milk plants in the various regions of the country.

In the opinion of the mission, it seemed clear that the Government's dairy development strategy and the preliminary plans for its implementation were basically sound, and as a result the Government was enabled to: obtain finance and technical assistance from bilateral and international sources; receive assistance from the World Food Programme; and undertake more integrated action for dairy development.

Implementation. The implementation of the NDDP is the responsibility of the Empresa de Industrias Lácteas (Dairy Industries Enterprise) which is part of the Bolivian Development Corporation, a state body involved in the industrial and agricultural development of the country.

For the purposes of dairy development the country has been divided into three geographic regions (Figure 1).

Zone I:	Departments of La Paz, Oruro and Cochabamba.
Zone II:	Departments of Sucre, Potosí and Tarija.
Zone III:	Departments of Santa Cruz, Beni and Pando.

These regions have been determined on the basis of their milk potential, their geographic proximity and ease

Swiss cattle pasturing in the Bolivian Altiplano

of communication, and the objective of local self-sufficiency in milk products.

The targets of the NDDP for a period of seven years can be summarized as follows:

- creation of an industrial infrastructure through the construction of milk plants in the various regions of the country;
- increase in per caput milk consumption from 12 to 14 kg/person/year;
- commercial self-sufficiency by increasing the availability of raw milk;
- increase in milk production at regional and local level by providing the producer with technical assistance, planting pastures, importing dairy cattle and improving existing breeds, extending loans to dairy producers, and raising the average milk yield to 3 500 kg per lactation;
- training technical personnel working in milk plants and in the field

In short, what the plan seeks to do is to rationalize production, processing and marketing of milk products throughout the country.

The main sources of finance for implementing the plan are:

	(US$1 000)
National	
Bolivian Development Corporation	3 450
Tesoro General de la Nación (National Treasury)	470
Banco Central de Bolivia	1 620
Banco Agrícola de Bolivia	500
Bilateral	
Government of Denmark	10 900
Government of Switzerland	274
International	
World Food Programme	625

Results achieved to date

With regard to the industrial infrastructure, the construction of the new milk plants in the departments of Santa Cruz, Sucre and Tarija and the extension of the Cochabamba plant were completed on schedule, and the installation of machinery is so well advanced that all five plants will come into operation in 1977. Both the feasibility studies for the plants and the technical specifications for the machinery and equipment were prepared entirely by Bolivian technicians from the Empresa de Industrias Lácteas. The Cochabamba and La Paz plants are managed commercially and receive no subsidy, the annual profits being reinvested in the sector.

The measures undertaken to promote milk production at regional and local level have also produced some positive results.

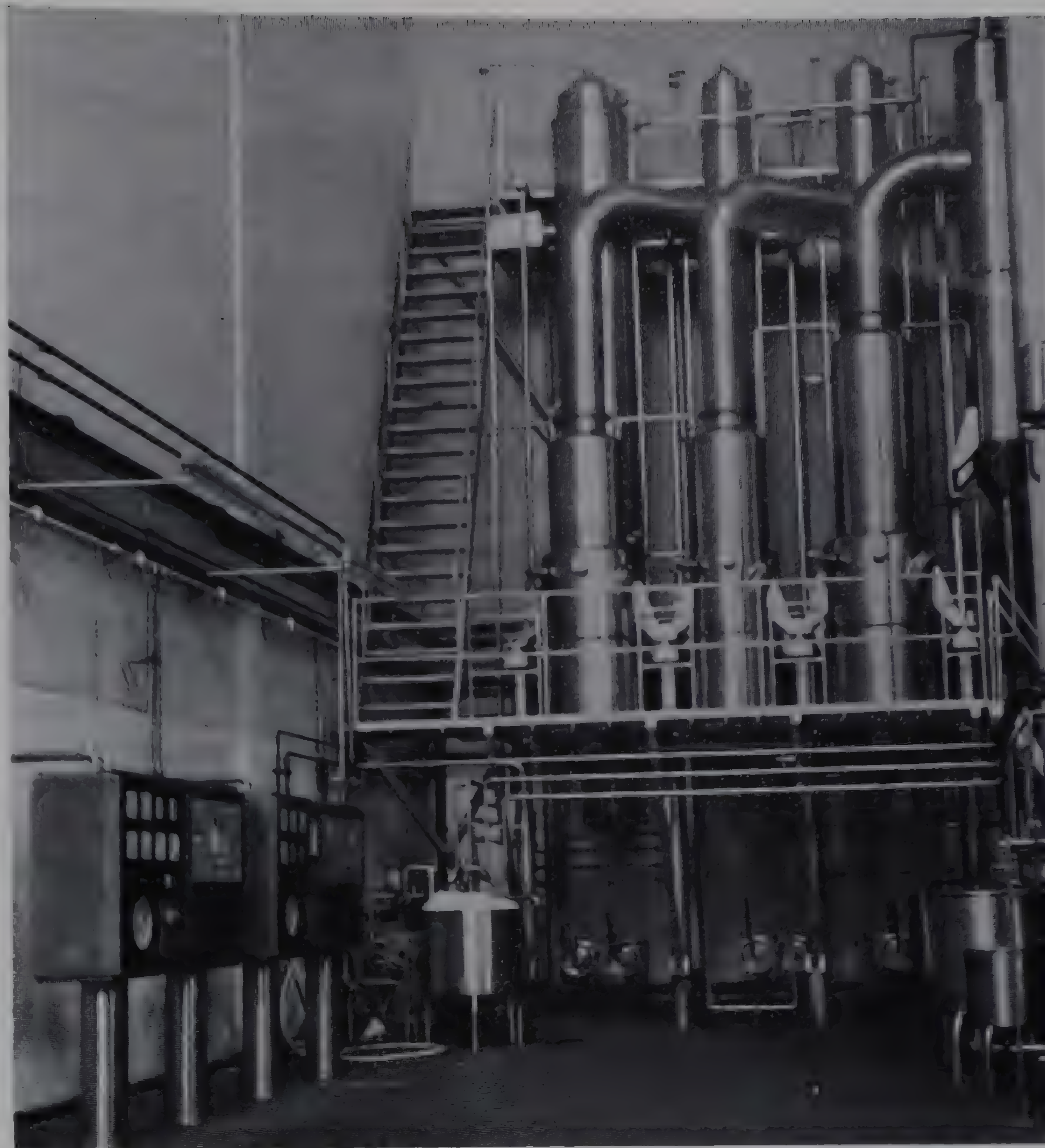
In Cochabamba for example the Bolivian Development Corporation/Swiss Technical Cooperation/WFP Dairy Development Programme has managed

to stabilize milk production throughout the year, avoiding the seasonal fluctuations which previously took place (Figure 2). This has been made feasible by an effective campaign for the construction of silos (20 000 metric tons were ensiled in 1976). This programme provides the producer with: free technical assistance, sale of inputs, hire of agricultural machinery from a pool, and sale of concentrate feeds for cattle.

The assistance provided to the Cochabamba producers has resulted in an annual rate of increase in production exceeding 25 percent during 1975 and 1976.

The promotion of milk production on the Altiplano has also met with some success which, taking into account the limiting factors in this zone, reflects the effort made. In January 1973 only 12 producers were delivering milk to the plant in La Paz (PIL-LPZ)[1]; in December 1976 the number of milk producers had risen to 671. The sum paid in 1973 by PIL-LPZ to milk producers was 118.5 thousand Bolivian pesos (approximately US$5 800); in 1976 this figure rose to over 3 million Bolivian pesos (approximately US$ 150 000).

Another aspect worth mentioning is the training of technical personnel and workers for the milk plants. Twelve engineers from the Empresa de Industrias Lácteas have taken part in milk-processing courses sponsored by FAO and the Government of Denmark; all these technicians are now working in milk plants. Qualified workers for these new plants were trained in the Cochabamba and La Paz plants by Bolivian instructors.



MACHINERY IN THE COCHABAMBA MILK PLANT

Conclusions

These results show that the targets of the plan concerning the industrial infrastructure have been fully achieved. The measures to promote milk production have not been so spectacular and must be intensified and extended to ensure that the milk-processing plants now in operation or under construction receive a supply of raw material sufficient in quality and quantity to guarantee compliance with the basic objectives of the plan. The new loan of Danish Crowns 40 million (approx. US$ 678 000) granted by the Government of Denmark to Bolivia will undoubtedly make a most effective contribution to the promotion of milk production at regional and local levels to achieve harmonious, integrated, balanced and sustained development. ■

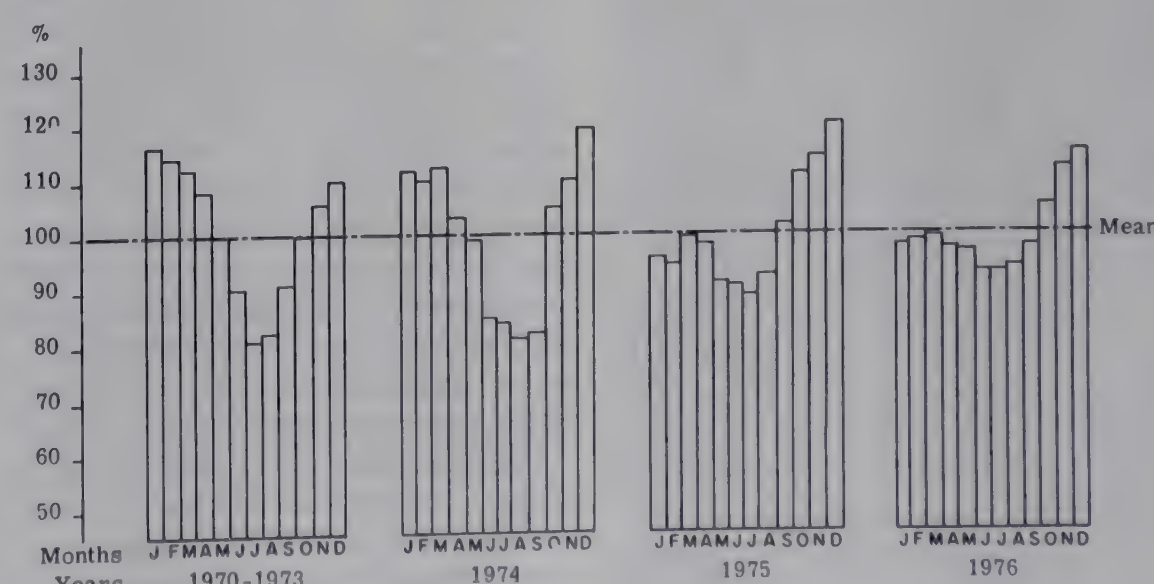


FIGURE 2. — *Amount of milk delivered to the plant each month, expressed as percentage fluctuations around the monthly average.*

[1] PIL-LPZ: Planta Industrializadora de Leche de La Paz (La Paz Milk Processing Plant).

Current situation and outlook for animal feeds and animal products *

☐ CEREALS

World cereal supplies will again be ample in 1977/78. Sizeable stocks were carried over from 1976/77, and it now looks very probable that the 1977 cereal harvest will, for the second year in a row, be above current consumption requirements.

Information received during the last quarter confirms the early FAO forecast of another large world crop of grains in 1977. At 1 128 million tons, aggregate world production of cereals (excluding rice) is forecast at only marginally below last year's record and, for the second year running, above the long-term trend value. A decline in world wheat production is almost entirely balanced by the expected increase in coarse grains output, currently forecast at 723 million tons (1976: 715 million tons).

The crop estimates are now becoming more reliable for crops grown in the Northern Hemisphere, where wheat, barley, oats and rye have mostly been harvested and maize and sorghum are in an advanced stage of growth. For crops grown in the Southern Hemisphere forecasts remain tentative.

In the United States the maize crop estimate was reduced by 6 million tons from the July estimate to 154.7 million tons, still a large crop but below the 1976 record of 157.9 million tons. Estimates for other coarse grains were increased substantially. For this reason total U.S. coarse grain production is estimated to be marginally larger than in 1976.

In Europe the wheat crop is as large as in 1976 and the coarse grain crop has more than recovered from the drought-reduced 1976 level. The increase is mostly in the EEC, where the wheat and coarse grain crop is estimated at 105 million tons, 14 million tons above 1976. In eastern Europe the wheat and coarse grain crop is currently forecast at about 80 million tons, against 78.4 million tons in 1976. The U.S.S.R. is harvesting a cereal crop which is expected to yield 220 million tons, only marginally less than last year's record.

In the Far East some reduction from last year's record grain crops is anticipated. Prospects for the Indian Kharif coarse grains are still uncertain, as the abundant monsoon rains might have adversely affected yields. In Thailand, owing to late and scanty monsoon rains, the maize crop is now estimated at only 1.9 million tons, against 2.7 million tons in 1976.

In east Africa good maize and sorghum crops are being harvested in most countries.

In Australia barley, oats and maize production is also expected to increase, while some decline is forecast for sorghum.

World coarse grain imports in 1977/78 are currently expected to fall by about 12 percent to 67 million tons, the lowest level since 1974/75. This is mainly a result of lower requirements by western and eastern Europe and the U.S.S.R. Larger imports are anticipated for Japan, the Republic of Korea and Egypt.

The most important development in the trade outlook for coarse grains in 1977/78 is in the position of the EEC. Because of the recovery in maize production and the large increase in barley production, EEC coarse grain imports from third countries are estimated to fall by 9 million tons below 1976/77 to 16 million tons. At the same time, exports of coarse grains (mainly barley) by the Community are currently expected to reach 2.8 million tons, as compared with only 0.6 million tons in 1976/77. Thus net imports from third countries by the EEC are forecast to decline from 24.4 million tons in 1976/77 to 13.2 million tons this year.

On the basis of present 1977 crop production and consumption estimates, carry-over stocks of cereals are tentatively forecast to increase by a further 22 million tons by the end of the 1977/78 seasons and to reach a total of 182 million tons, equivalent to about 20 percent of annual consumption. While stocks of wheat and rice are likely to increase only marginally, stocks of coarse grains are currently expected to rise by 19 million tons, mainly reflecting the record world harvest of these grains and the lagging growth of feed consumption. The fall in coarse grains prices has accelerated in recent months.

Compared with a year earlier, latest quotations for maize and sorghum are respectively 32 and 23 percent lower. Maize quotations have fallen by 10 percent in the last month alone.

The prospect of record supplies of coarse grains and lagging demand, leading to substantial stock accumulation, are probably the main reasons behind the substantial fall in maize and sorghum prices. The forecast of a soybean crop well above market expectations which caused a sharp fall in the prices of soybeans and soybean products has also contributed to the decline in coarse grain quotations.

☐ OILSEEDS, CAKES AND MEALS

The upward trend in international prices of most oilseeds and products early in the year has been sharply reversed since May. Factors contributing to this rapid fall in prices include: a reduction of demand for soybeans in the United States and western Europe; the arrival on the export market of newly harvested crops, primarily from Brazil and Argentina; generally declining grains prices; and prospects of a record production in the 1977/78 season.

Current prospects for the 1977/78

* As of 22 August 1977.
Source: FAO Commodities and Trade Division

season suggest that, given a continuation of reasonable weather, harvests will be larger than in 1976/77. But Northern Hemisphere annual crops will remain exposed to the vagaries of the weather until the actual harvest later in the year, and Southern Hemisphere annual crops have still to be sown.

The major expansion is expected to occur in developed countries, particularly as a result of substantially larger crops in North America. Output in developing and centrally planned countries is expected to increase more moderately.

By far the largest increase is forecast in world production of soybeans, mainly because the United States harvest is expected to recover and attain a new record, after the unusually poor crop of the preceding season. In its August report, the USDA forecasts a crop of 43.6 million tons, 27 percent more than last year; however, carryover stocks at the beginning of the 1977/78 season will probably have fallen to near minimum working levels. Hence the total supply of beans might be only 11 percent above the previous season, but still 3 percent below the record level of the 1975/76 season. Apart from the United States, a further (but probably moderate) increase is forecast in the 1978 Brazilian soybean crop. Larger crops are also expected in Argentina, Paraguay and Mexico.

World production of cottonseed is expected to increase, mainly following prospects of a continuing recovery in the United States. Further increases are also likely in the largest producing countries of South America in response to relatively favourable prices.

World groundnut production will probably exceed 1976/77 levels, particularly if weather conditions in India continue to develop favourably. Sunflowerseed production is expected to increase in the U.S.S.R. after two seasons of reduced crops.

A substantial recovery is expected in the world rapeseed crop. Canadian production is currently forecast at some 35 percent above the preceding year, but supplies and export availabilities will be smaller than in the preceding season owing to a drastic reduction in opening stocks.

Copra output and export are expected to resume their long-term upward trend, after the setback in 1977 due mainly to a reduced production in the Philippines following insufficient rainfall.

World production of oilcakes and meals in 1977/78 is expected to grow substantially owing to the predominant share of soybeans (with a high protein meal content in comparison with other oilseeds) in the overall expansion of oilseed crops expected next season. Production is tentatively forecast at a record 36 million tons (protein equivalent), 5 million tons (15 percent) larger than this year and 2 million tons above the long-term trend. With regard to fish meal some recovery may be expected in Peru following the poor catch so far this year. However, total world availability of cakes and meals will not increase commensurately, as beginning stocks will be far smaller than a year ago.

□ MILK AND MILK PRODUCTS

Notwithstanding a recent reduction of surpluses, the international dairy situation is likely to remain one in which supplies substantially exceed commercial outlets. In 1977/78 world milk output is expected to rise at a somewhat faster pace. Stocks of milk products are now tending to grow again in developed countries, and prices in international dairy trade will remain low.

In the first half of 1977 milk output of developed countries rose by less than 1 percent, mainly owing to unfavourable feed conditions. Growth rates were higher in developing and centrally planned countries, especially in the U.S.S.R. where milk deliveries increased by as much as 13 percent. Nonetheless, these two groups of countries increased their purchases of dairy products from developed countries. At the same time, in the developed regions, with the major exception of the United States, rising domestic demand for cheese absorbed more milk, so that their butter and skim milk powder output was markedly reduced; thus, in spite of further decreases in consumption, butter stocks did not grow significantly. Skim milk powder stocks have actually been reduced substantially this year, helped by continuous large-scale and costly disposals in the feedstuffs sector.

The decline in exportable supplies of milk products and the increase in import demand, notably from the petroleum-exporting developing countries, resulted in a further rise in prices in international dairy trade. However, current f.o.b. prices of butter and skim milk powder, for instance, at around US$1 050 and $425 per ton respectively, are still only about one third of domestic market prices in western Europe and North America.

For the 1977/78 season milk production in western Europe has increasingly exceeded the previous year's level in recent weeks, reflecting better grazing conditions than during the 1976 drought summer. The relatively cool summer has also lowered the demand for liquid milk and fresh milk. The declining trend in butter and skim milk powder manufacture has, therefore, been reversed.

For the 1977/78 season as a whole the outlook is for increased production of milk in developed countries. In western Europe output is expected to rise somewhat faster than in 1976/77. Winter fodder supplies are likely to be greater and concentrate feeds cheaper than last year. Several western European governments have taken action to curb milk output, but, especially in the EEC, this is not expected to lead to a substantial reduction of production in the immediate future.

In Oceania New Zealand dairy farmers may not benefit again by such favourable weather conditions as last year, but production in Australia might recover. North American milk output may show a moderate growth in 1977/78, with United States production being stimulated by a marked rise in the milk support price. More milk is also likely to be produced in Japan.

With regard to domestic demand, prospects remain unfavourable in most developed countries. Unless encouraged by additional special measures, butter consumption will continue its decline, though probably at a slower pace. Liquid milk consumption may

also decrease in 1977/78; only cheese sales should grow further.

In this situation the reduction of developed countries' surpluses in 1976/77 is not expected to continue, and their stocks, especially of skim milk powder, are likely to remain excessive, unless massive surplus disposal action continues.

Skim milk powder will probably remain available for feeding to pigs and poultry at prices which make it competitive with soybean meal. In the EEC this will require a subsidy of almost 80 percent, while feeding of skim milk powder to calves will need a subsidy of some 40 percent. Assuming that current policy is pursued, dried and liquid skim milk, equivalent to approximately 2 million tons of skim milk powder, will be disposed of as animal feed in the EEC in 1977/78. Measures to stimulate butter consumption have been intensified this year, notably in the United Kingdom, where, with the help of a direct EEC subsidy, the butter price has been reduced by 16 percent.

The EEC, the United States, Canada and some other surplus producing countries will also continue to make milk products available for food aid programmes in developing countries. Over 200 000 tons of skim milk powder and 50 000 tons of butter oil are likely to be committed for food aid in 1977/78, compared with actual shipments of approximately 150 000 and 40 000 tons last year.

In centrally planned countries import demand is likely to shrink. Dairy cow numbers are rising, and improved feed supplies should help raise yields. Thus the recovery of milk output will probably gain momentum, and this region could turn from a net importer into a small net exporter in 1977/78.

In the developing world milk production is also expected to increase, particularly in Asia and Latin America. This, together with shortage of foreign exchange, will limit the dairy product imports of the poorer developing countries.

However, the outlook is for a continuous expansion of purchases by the oil-exporting developing countries, especially of whole milk powder, cheese and condensed milk; their imports of other dairy products are also increasing. In 1977/78 they may import milk products equivalent to over 3 million tons of milk, more than double the quantity imported before the oil price boom and about 15 percent of current annual world dairy imports.

□ MEAT

The expansion of world meat production has slowed down during the first half of 1977. With the exception of higher seasonal slaughterings in Europe, the expansion in meat production is likely to be even smaller in the remainder of this year.

The downward phase of the cattle cycles is continuing in nearly all major beef producing and importing countries throughout the world. Only in Poland, Romania and Bulgaria are cattle numbers increasing. There are signs that the liquidation phase will be continued well into 1978 and, in some countries, even into the first half of 1979.

Beef and veal output is likely to be about 1 million tons less this year than in 1976. The new EEC measures on non-deliveries of milk and conversion of dairy cow herds will tend to increase cow slaughterings, but it is too early to judge their short-term impact on beef output.

Mutton and lamb production is likely to be reduced, not only because of adverse weather conditions in the first half of this year in Oceania, but also because of the retention of animals for production expansion; many farmers are shifting back from beef production to mutton and lamb, which seem to have good trade prospects in the Near East market.

Pigmeat production cycles reached their peak in the first half of 1977 in most western European countries. Pigmeat output is not likely to increase during the remainder of the year and may be even slightly reduced in the EEC. Lower pigmeat output and limited beef supplies will somewhat strengthen prices for red meats. In North America the cyclical pigmeat expansion has been modest during the second quarter of this year, and in the next six to nine months output is likely to remain below that of the corresponding period in 1976/77.

The increase in poultry meat production in western Europe, already rather moderate for the first half of 1977, is forecast to be even slower in the second and third quarters of the current year. The low prices in the poultry meat sector are mainly a consequence of an uncertain domestic and export demand. In North America an expansion in poultry production of 5 percent may be expected. The tighter red meat supply situation is also favouring the poultry meat industry.

The expansion of world meat trade continued throughout 1976 and the first months of 1977, but recently, trade prospects have changed. Despite lower beef output and the slowdown in the expansion of pigmeat and poultry meat production in many importing countries, international trade in meat seems less active, as beef consumption in most western European countries is stagnating or even declining.

The forecast of EEC imports of beef and veal has been further reduced despite the introduction of the new common import regime which, *inter alia*, ended the ban on beef imports. It is unlikely that imports into the Community will increase because of the reintroduction of support measures for storing beef and pigmeat. EEC holdings of frozen beef in intervention stocks remain at a high level.

Most of the trade expansion in the first half of 1977 was due to higher exports from Oceania to the Near East, eastern European countries and the U.S.S.R. However, the U.S.S.R. and eastern Europe are expected to import less in the second half of the year than in the first; their own meat supplies are increasing, and they are reluctant to purchase at higher prices. Shipments from Argentina in 1977 are forecast at about 100 000 tons, 20 percent above last year's level, mainly owing to larger exports to European countries.

International meat prices are likely to increase slowly toward the end of the year. However, if demand for red meat strengthens in 1978, the present depressed price situation could be rapidly reversed, as supplies at that time will be limited. ■

Course in management and diseases of sheep

This training course is being organized in cooperation with the Animal Diseases Research Association and the Hill Farming Research Organization, and will be held at Bush Estate, Penicuik, Midlothian, Scotland, from 5 to 17 March 1978. It will be under the direction of Dr. J.T. Stamp of the Animal Diseases Research Association and Dr. J.M.M. Cunningham of the Hill Farming Research Organization.

The guiding theme will be raising the productivity of sheep through the application of modern knowledge to management and to the control of disease. The course will be an intensive one, and lectures will be supplemented by practical demonstrations and visits to farms and research stations. Adequate time will, however, be allowed for informal discussion.

The course is designed for experienced agriculturists and veterinarians from research, advisory and consultation services who are concerned with sheep production or regulatory medicine and are interested in the management and diseases of sheep. An opportunity for a limited number of course members to contribute short papers will also be available. The course fee is £330. It is a residential course, with members being accommodated at a hotel in Edinburgh.

Application forms can be obtained from the British Council or related institutions. ■

Sixth international course on dairy cattle husbandry

The sixth course of the series of international courses on dairy cattle husbandry will be held in the Netherlands from 14 March to 16 June 1978. Participants should have had university-level training in agriculture or veterinary science and three years' experience in dairy cattle husbandry or a closely related subject. The course will be conducted in English. Further information may be obtained from the Director, International Agricultural Centre (IAC), P.O. Box 88, Wageningen, the Netherlands. ■

The IV World Conference on Animal Production

The IV World Conference on Animal Production, sponsored and organized by the World Association for Animal Production and the Argentine Association for Animal Production, will be held at the Centro Cultural San Martín, Buenos Aires, Argentina, from 20 to 26 August 1978.

The main objectives of the conference are: to analyse the factors which determine the creation and application of scientific knowledge; and to discuss within this framework the impact and relevance of recent advances in research to increase the effectiveness of production systems.

The programme for the conference includes the following:

- 1.0 Bio-economic animal production systems in Latin America.
- 2.0 Effectiveness of animal production systems.
- 2.1 Construction and development.
  - 2.1.1 Identification and description.
  - 2.1.2 Availability of feeds.
  - 2.1.3 The roles of the available animals.
  - 2.1.4 Animal health and disease control.
  - 2.1.5 Socio-economic variables within systems.
  - 2.1.6 Modelling.
- 2.2 The socio-economic context in which animal production systems operate.
  - 2.2.1 Implementation of livestock development programmes.

Papers may be offered under any of the above headings or within the fields of pasture utilization, nutrition, breeding and genetics, physiology of reproduction and adaptation to the environment. Such papers should be sent in two copies, together with summaries, to the following address: General Secretariat, IV World Conference on Animal Production, Congresos Internacionales S.A., Reconquista 533, 6th floor, 1003-Capital Federal, República Argentina.

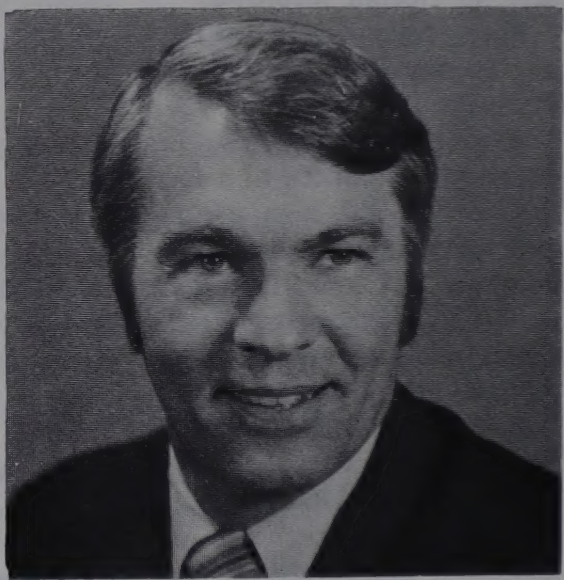
Papers will be received up to 28 February 1978.

Any additional information regarding submission of papers or generally about the conference should be requested from the secretariat. ■

New Division Director appointed

• Dr. H.C. Mussman, Associate Administrator of the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture, has been appointed as Director of FAO's Animal Production and Health Division as of September 1977. In his former position with USDA, he shared overall administrative responsibilities for federal animal health, plant protection and meat and poultry inspection programmes.

The new Director is a graduate of the University of Wisconsin and of Kansas State University, and holds both the DVM and Ph.D. degrees. He has served as a member of the faculty of the College of Veterinary Medicine, Kansas State University and of the Department of Veterinary Science, University of Nebraska. During his tenure at Nebraska, he spent three years in Colombia as Director of the University's veterinary project.



Dr. H.C. Mussman

Dr. Mussman is a member of the American Veterinary Medical Association, the American Society for Microbiology and the New York Academy of Science, in addition to a number of honorary scientific societies.

He will also serve as Chairman of the Editorial Advisory Committee of *World Animal Review*. ■

The yak: its role in the economic and cultural life of breeders in central Asia

Edited by Société d'ethnozootechnie, 25 boulevard Arago, Paris. No. 15, 1976. 170 pages. (In French)

This booklet represents the proceedings, with additional contributions, of a meeting of the Société d'ethnozootechnie held in Paris on 5 March 1976. Although there are 14 contributions by 11 authors, the moving spirits and majority authors are clearly C. Jest and J. Bonnemaire.

The first article gives a historical account of the gradually increasing knowledge of the yak brought back by travellers and naturalists from the time of Aelianus and Pliny up to the 19th century. There follows a series of extracts from various writers describing the mythology of the yak in Tibet and its place in legend, iconography and ritual, supplemented by a short account of the uses of yak products in Tibetan medicine.

Then follow two articles by Bonnemaire devoted to the wild and domestic yak. The wild yak is now almost extinct; it is reduced to a few thousand in the high mountains of northern Tibet. The domestic yak, on the other hand, is an extremely important agricultural animal in the mountainous areas of central Asia: Tibetan plateau (Tibet and southwest China), Himalayas (Nepal, Bhutan and India), Pamirs (northeast Afghanistan and southeast Tajikistan), Tien-Shan (eastern Kirghizstan) and the mountains of western Mongolia. This article also includes an account of the hybridization of the yak with other bovine species.

Later articles describe the breeding and production systems used in Nepal, Afghanistan and Mongolia. The booklet concludes with a bibliography of 289 references on the yak, an index of Tibetan terms used to designate the yak and its hybrids, and an English summary.

It should be clear that while this book is not the last word on the yak, since it has no personal contribution from Tibet where most yaks are found, it is the most comprehensive account of the species yet produced. It should be of interest to anthropologists and historians, in addition to zoologists and agriculturists. The 60 well-produced photographs of early illustrations and of the modern yak and its environment give the book an instant appeal.

I.L.M.

Single cell proteins from cellulose and hydrocarbons

By P.J. Rockwell. Chemical Technology Review No. 74 and Food Technology Review No. 34. Noyes Data Corp., Park Ridge, N.J. 07656, United States, 1976. 337 pages, numerous tables, figures, examples and references. Indexes for companies, inventors and U.S. patent numbers. Price: U.S.$39.00. (In English)

This book constitutes a review of the rapid growth of microorganisms on readily available substrate material in a plant operation under closely controlled conditions and the recovery of edible protein therefrom. The publication is divided into two parts according to substrate sources for the microorganism culture: cellulose and hydrocarbons. Part I is concerned primarily with a process developed at Louisiana State University (LSU) for culturing and then harvesting microorganisms using sugarcane bagasse as the carbon source. First, an assessment is given of the availability of cellulose materials, their physical properties and fermentation characteristics. The systematic description of the LSU Project then includes substrates used and methods for their pretreatment, organisms and culture media, fermentation methods and product harvesting. An account is also given of the design and operation of the LSU pilot plant. The two remaining sections of Part I are dedicated to protein isolation from single cell organisms (SCP) and to an assessment of the economic potential of SCP.

The technology for SCP production from hydrocarbon sources is in a relatively advanced state and many processes have been described in the patent literature. Part II of this book therefore presents in a condensed form most of the U.S. patents granted in this field over the past two decades. This material is an updated version of "Proteins from Hydrocarbon" by S. Gutcho in Food Technology Review No. 6 (1973) and contains much added recent process information. As in the previous book, the main sections are concerned with the growth of the cells on a variety of hydrocarbon feedstocks (liquid, gaseous and solid hydrocarbons), and the fermentation process, describing procedures to promote microbial growth, specialized equipment and techniques for the use of various nutritional sources, separation of the cells from the fermentation media, removal of residual hydrocarbons from the microbial mass, and recovery of proteins from the cells.

The section on special microorganism strains is completely new and contains recent patents concerning specially developed strains of organisms for the improved production of protein. The last section on recovery and processing techniques contains a number of recent processes designed to eliminate problems with odour, taste and texture usually associated with SCP from hydrocarbons.

For all those seriously interested in techniques for SCP production, this is a useful reference.

L.M.

Poultry diseases

Edited by R.F. Grodon. Baillière Tindall, London, 1977. 352 pages. Price: £9. (In English)

The book is prepared primarily for veterinary undergraduates but will be useful to those taking further degrees and also to those engaged in the poultry industry as veterinary advisers or practitioners; it should also be of value to agricultural students specializing in poultry science. The book is largely based on the papers prepared by the staff of the Houghton Poultry Research Station, covering avian diseases of major economic importance. The book is, however, not designed for the specialist avian pathologist.

Diseases are divided into the following 11 groups: bacterial, viral, parasitic and fungal diseases, nutritional disorders, diseases of unknown aetiology, constitutional disturbances, diseases of turkeys, skeletal disorders, diseases of the duck, and of birds other than domestic poultry. Additional chapters cover disinfection, disinfestation, hatchery hygiene, SPF poultry, chick embryo in research, artificial insemination and poultry meat hygiene.

The book sets out to provide an account of disease conditions as encountered in the field and does not include laboratory techniques or an account of nutritional and genetic factors. However, it does include data useful to the practitioner such as Acts and Orders, the Welfare Code and notes on poultry meat inspection.

Y.O.

Index for Nos. 21 to 24, 1977

Subject

Author

NOTE: The first number refers to the issue, the second to the page.

FAO SALES AGENTS AND BOOKSELLERS

Antilles, Netherlands	Boekhandel St. Augustinus, Abraham de Veerstraat 12, Willemstad, Curaçao.
Argentina	Editorial Hemisferio Sur S.R.L., Librería Agropecuaria, Pasteur 743, Buenos Aires.
Australia	Hunter Publications, 58A Gipps Street, Collingwood, Vic. 3066; The Assistant Director, Sales and Distribution, Australian Government Publishing Service, P.O. Box 84, Canberra, A.C.T. 2600, and Australian Government Publications and Inquiry Centres in Canberra, Melbourne, Sydney, Perth, Adelaide and Hobart.
Austria	Gerold & Co., Buchhandlung und Verlag, Graben 31, 1011 Vienna.
Bangladesh	Agricultural Development Agencies in Bangladesh, P.O. Box 5045, Dacca 5.
Barbados	Cloister Bookstore Ltd., Hincks Street, Bridgetown.
Belgium	Service des publications de la FAO, M.J. De Lannoy, rue du Trône 112, 1050 Brussels. CCP 000-0808993-13.
Bolivia	Los Amigos del Libro, Perú 3712, Casilla 450, Cochabamba; Mercado 1315, La Paz; René Moreno 26, Santa Cruz; Junín esq. 6 de Octubre, Oruro.
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Dominican Rep.	Fundación Dominicana de Desarrollo, Casa de las Gárgolas, Mercedes 4, Santo Domingo.
Ecuador	Su Librería Cía. Ltda., García Moreno 1172, Apartado 2556, Quito.
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Finland	Akateeminen Kirjakauppa, 1 Keskuskatu, Helsinki.
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Ghana	Fides Enterprises, P.O. Box 1628, Accra.
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